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RIVER FISHING METHODS

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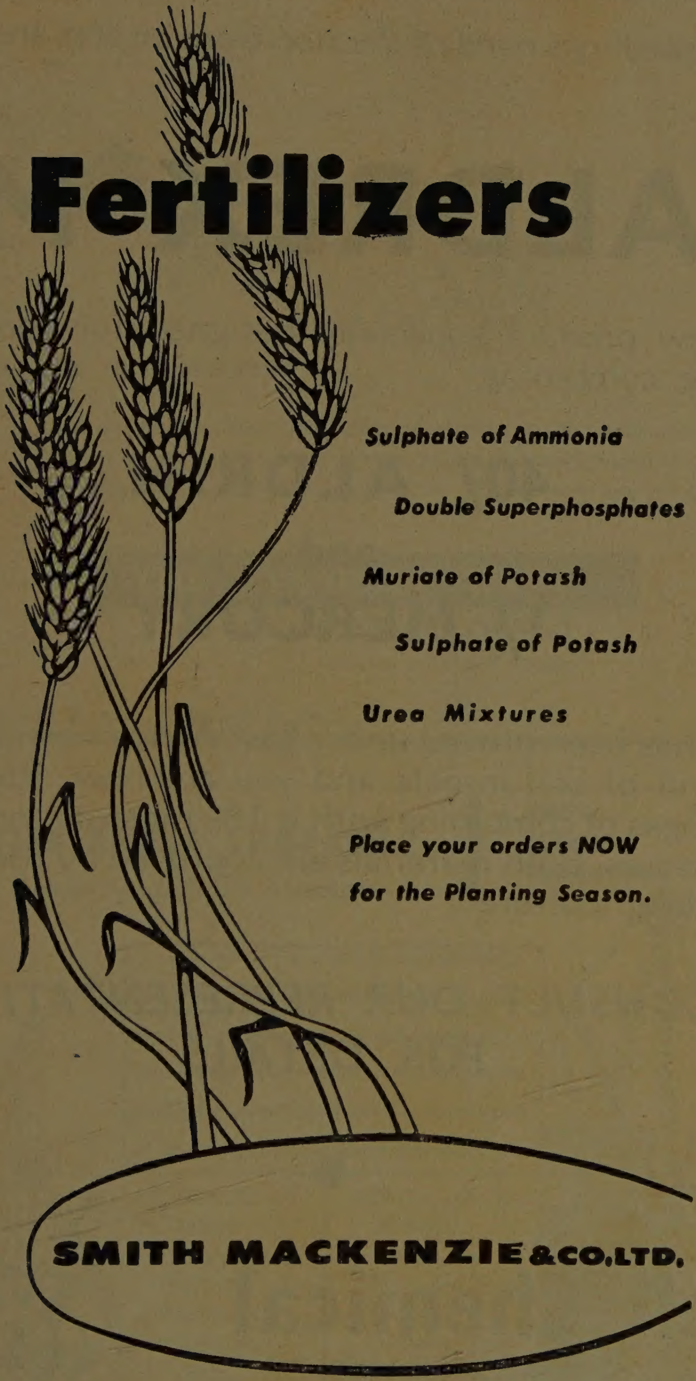

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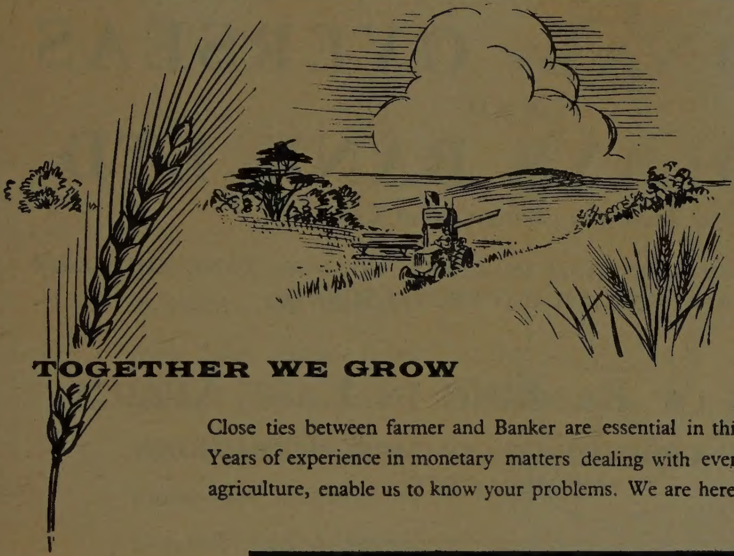

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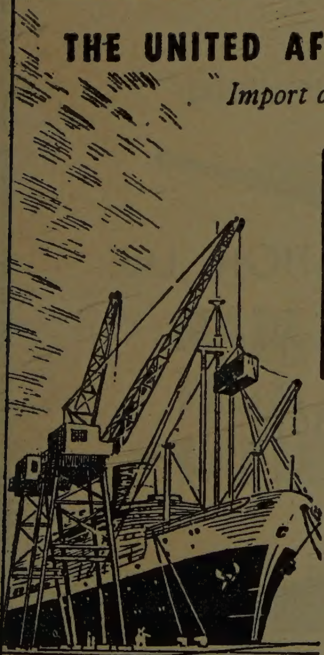

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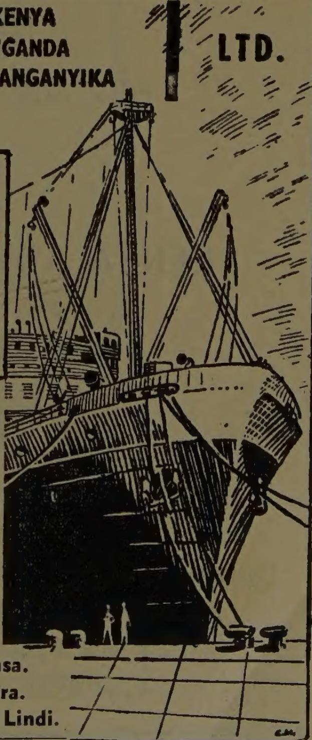

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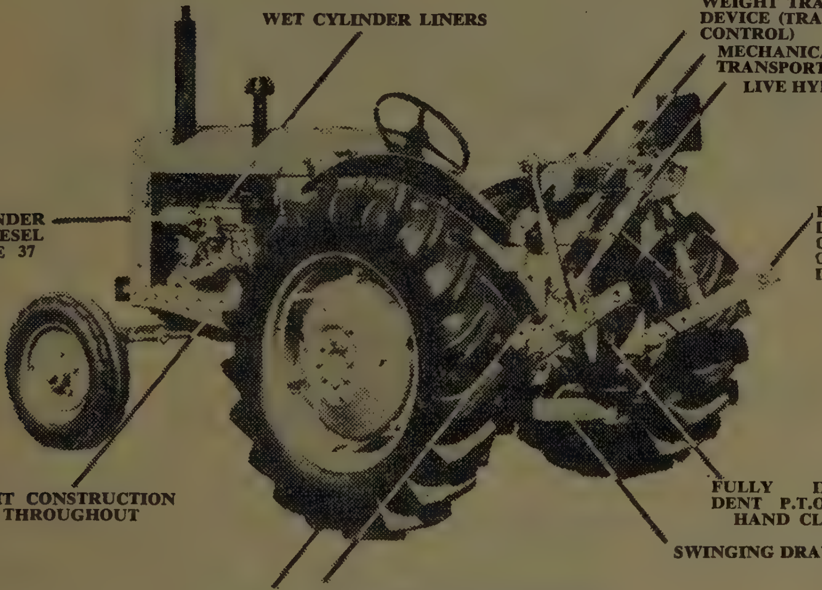
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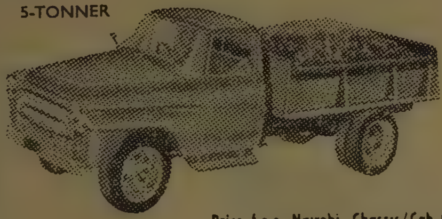

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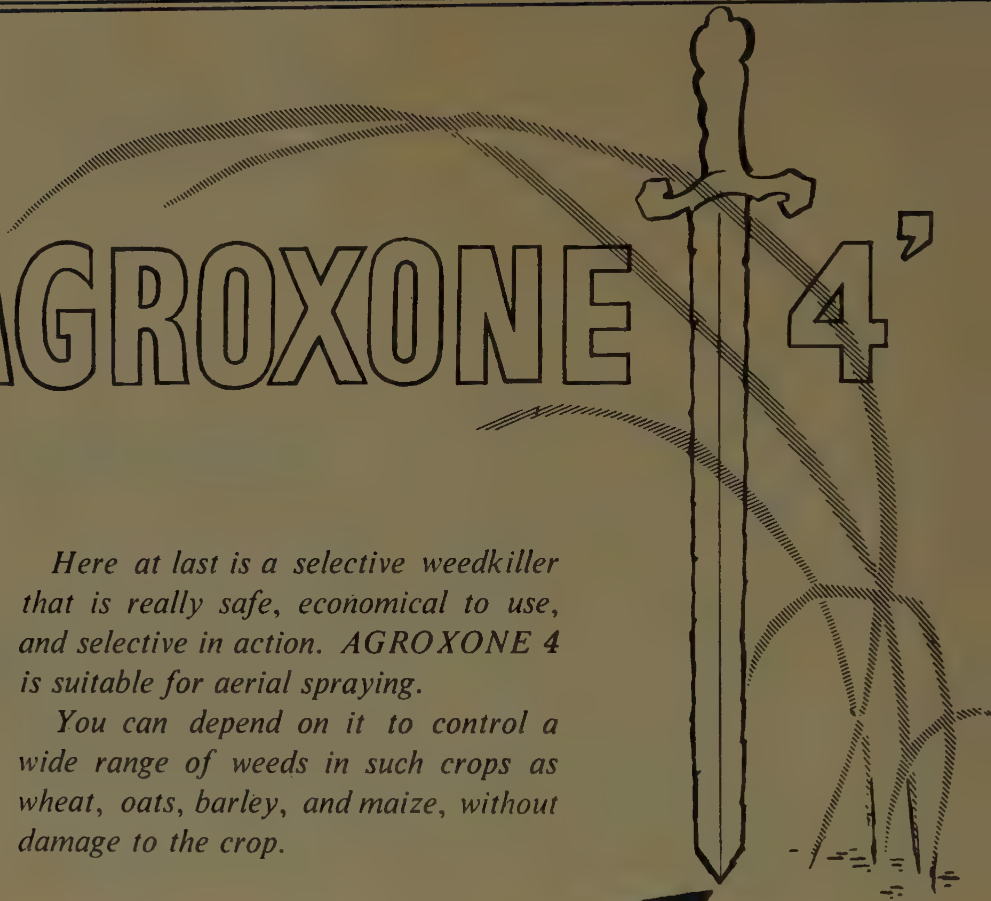

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Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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NOTES ON KENYA AGRICULTURE

IV.—FRUITS AND VEGETABLES

By **T. H. Jackson, R. H. Bennison, and H. R. Evans (Department of Agriculture, Kenya)**

Crop	Spacing	Seed Rate per acre	Yield per acre	Time to Maturity
BANANA	9′ x 9′ (dwarf)	530 plants	1–3 bunches per plant per year	12–15 months.
	12′ x 15′ (tall)	302 plants		12–15 months.
CHILLIES:				
C. minimum	3′ x 2′	¾ lb.	800–1,400 lb.	5–6 months.
C. frutescens	3′ x 2′	¾ lb.	2,000–2,800 lb.	5–6 months.
CITRUS	25′ x 25′	—	—	8–10 years.
PAWPAW	7′ x 7′	¾ lb.	50–140 lb.	9–15 months.
PINEAPPLE	2′ x 1′ x 3′	17,000 plants	30–35 tons over 3 years	18–22 months.
ONION	12″ x 4″	2 lb. transplanted	Large vars. 7–12 tons	4–6 months.
ASPARAGUS	7′ x 1′	5 lb.	1,500–2,000 lb.	3 years.
	Brassicas			
CABBAGES	18″ x 18″	¼ lb.	6–7 tons	70–80 days.
Mid-season	30″ x 18″	¼ lb.	7–8 tons	90–100 days.
Late	30″ x 30″	¼ lb.	8–10 tons	120–130 days.
CAULIFLOWER	30″ x 18″	½ lb.	5–6 tons	100–120 days.
BRUSSEL SPROUTS	30″ x 36″	½ lb.	4–5 tons	160–170 days.
	Root Crops			
CARROTS	12″ x 3″	3–4 lb.	5–6 tons	3 months.
BEETROOT	12″ x 3″	4–5 lb.	5–6 tons	3 months.
PARSNIP	15″ x 4″	4–5 lb.	6–7 tons	4 months.
TURNIP	18″ x 4″	1½–2 lb.	6–7 tons	3 months.
	Legumes			
PEAS	7″ x 1″	1 cwt.	2–3 tons	3 months.
DWARF BEANS	15″ x 4″	60 lb.	2–3 tons	4 months.
BROAD BEANS	15″ x 6″	80 lb.	3–4 tons	5 months.
LIMA BEANS	24″ x 6″	60 lb.	4–5 tons	4 months.
	Salads			
LETTUCE	12″ x 8″	¼ lb.	1–2 tons	3 months.
CELERY	24″ x 8″	2 oz.	2–3 tons	6 months.
	Cucurbits			
PUMPKIN	4′ x 5′	¾ lb.	6–7 tons	4 months.
CUCUMBER	4′ x 5′	½ lb.	5–6 tons	3 months.
MELON (CANTALOUPE)	5′ x 6′	1 lb.	3–4 tons	3 months.
MELON (WATER)	8′ x 4′	¾ lb.	6–8 tons	3 months.

BANANAS (*Musa sapientum*) Kiswahili—Ndizi

Climate and Soils

A regular evenly distributed supply of soil water is required, with high temperature and humidity in the absence of wind. Where there is a danger of high winds dwarf types should be grown. The ideal soil is a deep loam permitting free root development. Rainfall 45-100 in. Altitude 0-6,000 ft.

Cultivation

The land should be well ploughed and harrowed or forked prior to planting. All couch and such like grasses should be completely removed. In areas of good rainfall, planting pits need only be 1½ × 1½ ft. spaced 10 × 10 ft. square. In drier areas, bananas can often be established more quickly by planting in pits 4 ft. wide by 3 ft. deep into which plenty of litter is thrown to keep the subsoil moist.

On sloping land, sound conservation practices must be adopted from the outset if the bananas are to develop satisfactorily. Planting is done by means of suckers, which should be removed from the parent plant with minimum damage to the bulb. Only two eyes should be left on opposite sides of the sucker. The sucker should be planted at an angle of 45° in the bottom of the 1½-ft. pit with the two eyes on opposite sides of the sucker (not above and below the sucker). The sucker is then covered with soil and a slight mound made to allow excess water to run off instead of accumulating in the hole. The ground between banana plants should never be kept bare. Limited growth of harmless weeds or inter-cropping with pulses is preferable. Best of all is to protect the soil with a good layer of mulch. Excessive suckers should be removed without damage to the parent plant. The aim should be a bearing stem and three followers at equal intervals of four months commencing from the time the first bunch has formed.

Major Uses

Fresh fruit, cooked fruit, banana flour and native beer. The stems are a useful cattle fodder and being high in potash are useful as an antidote when cattle are suffering from snake-bite.

CHILLIES (*Capsicum*)

Two main types are grown commercially.

(*a*) Small, very hot "Bird chillie"—*C. minimum*—Kiswahili Pilipili hoho.

(*b*) Medium length 3-4-in. type, not as hot—*C. frutescens*—Kiswahili Pilipili.

Cultivation and Soil

Both types require an open well-tilled soil, well supplied with humus. Not suited to high rainfall areas. Will grow well from 0-4,500 ft. above sea-level. May be sown in beds and transplanted if care is taken not to damage the tap-root. Usually planted at stake at 2 × 3 ft. apart.

Harvesting

If good export demand is to be maintained, particular care is needed to ensure that only bright-red fruits well dried and free from discoloured pods stems, and dirt, are exported. Yield 800 to 1,400 lb. per acre for small type and about 2,000 lb. per acre for larger type. Latter fetches lower price but may be better proposition owing to higher yield and ease of harvesting.

Major Uses

Cayenne pepper, pharmaceutical purposes, flavouring in canned products.

CITRUS

Orange, *Citrus sinensis,* Kiswahili Mchungwa
Lemon, *C. limon,* Kiswahili Limau
Lime, *C. aurantifolia,* Kiswahili Ndimu
Grapefruit, *C. paradisi,* Kiswahili Mdanzi
Tangarine, *C. reticulata,* Kiswahili Mchenza

Climate and Soils

Under coastal conditions all species of citrus grow well, but the steadily high temperatures of 75° F. and over produce a fruit of poor colour and flavour although very sweet. Grapefruit develop their best flavour and colour at 2-3,000 ft.

A medium loam is the most suitable for citrus although the trees will thrive on the sandy soils of the Coast. For reasonable yields, a rainfall of 45 in. or more is required and irrigation is essential for consistent cropping.

Cultivation

Production of varieties budded, usually on rough lemon, is normal practice, but for African requirements seedlings are more suitable. Seed from selected trees is sown in beds and shaded. When 2-3 in. high off-types and weak seedlings are destroyed. At transplanting when 9-12 in. high a further discard of weaklings and those with twisted roots is done. The transplants are planted at 3 × 1¼ ft. and grown on for further year to 15 months when distribution takes place during the long rains.

The seedlings should be planted in a hole to which manure has been added. The trees should be shaded and protected from the wind and watered if no rain falls.

Spacing should be 25 × 25 ft. or slightly more on good soils.

Cropping will start in 6-8 years.

Harvesting

Orange, tangarine, grapefruit should be harvested when a certain amount of yellowing takes place. They will not colour fully. Lime and lemon can be harvested immature if required. Care should be taken to avoid bruising and, if possible, the fruit should be cut from the tree with secateurs.

At full bearing, an orange will yield 8-900 fruit, lemon 1,000, tangarine 12-1,500, lime 2-2,500 and grapefruit 6-700 fruit.

Major Uses

Greater proportion of the fruit is used for dessert purposes. Juice extraction from poor quality fruit is used for the fresh juice and squash trades and extraction of essential oils from the skins for flavouring.

PAWPAW (*Carica papaya*) Kiswahili—Papayi

Climate and Soils

Requires a deep, loamy soil, on flat or gently sloping land which should be well manured. Altitude 0-4,500 ft. Requires well distributed rainfall or irrigation to maintain production during dry spells. Is susceptible to cold or drying winds.

Cultivation

Planting is usually done at stake allowing six or more seeds per hole. Four or more plants should be grown on until the sex is known when the strongest female is retained. Leave one male to every 50 female plants.

Harvesting

Tapping commences at 9 to 15 months old, or when the fruits are 4 to 5 in. in diameter, by means of incisions ⅛ in. deep made in the fruit. Usually done by means of a razor blade embedded in a stick. The latex drips on to white cloth held in a frame which is clamped round the stem of the plant. Tapping continues at weekly intervals for 2-2½ years. Tapping is best done during early morning when the latex flows better. The latex is then collected and dried immediately in a kiln at a temperature of approximately 100° F. for 24 hours. The dried papain is a granular powder which should be packed in airtight tins as soon as possible—usually four-gallon tins.

Major Uses

Papain is used for tenderizing meat, invalid foods, removing cloudiness from beer, preventing shrinkage of fabrics, etc.

PINEAPPLE (*Ananas Sativus*) Kiswahili—Nanasi

Climate and Soils

Will grow in wide range of frost-free climates. Does well on coastal sands but fruit is unsuitable for canning. Best altitudes 5,000 to 5,800 ft. with rainfall of 30 in. and over. Trials at 3,000 to 3,500 ft. with 25-in. rainfall show promise of success. Can be grown on wide range of soils but only commercially successful on soils of high fertility. Good drainage essential. On bench terraces avoid planting in pockets where water stands or on the back half where subsoil has been exposed unless the soil has been well manured. Pineapples should not follow gross feeders such as maize, unless the land has been heavily manured. Manuring is unnecessary on good virgin soil.

Cultivation

Land should be cultivated to depth of 1 ft. Essential that couch is completely eradicated. Planting done by suckers, slips or fruit crowns, the last two being best. Select material for uniformity of size, preferably medium-sized, well-shaped and sturdy, from plants producing large, shapely fruits. Avoid plants producing large numbers of slips. Planting material takes more quickly if dried for 14 days in the sun beforehand. Strip off base leaves from slips and crowns to expose ¾ in. of base tissue, and place base upwards in the sun. Can be kept thus for 14 to 60 days but shading may be necessary to prevent excessive drying. Planting distance 2 ft. × 1 ft. with 3 ft. between double rows = 17,000 plants per acre.

Plant 1½ in. deep for crowns and slips and 3 in. for suckers and press soil firmly round the shoot. Keep free from weed competition at all times but avoid deep cultivation. "Plant crop" fruits after 18-21 months continuing for as long as nine months. "First ratoon" crop fruits 11 months after this, lasting up to 11 months. Total, 52 months. A second ratoon crop may be taken if the plants are very vigorous.

Harvesting

Avoid over-ripe fruit. During the hot, bright seasons choose fruit beginning to turn yellow at base and during the cold, dull seasons the fruit will not be ripe until the shell is almost fully coloured. Avoid bruising in handling. Deliver to cannery as soon as possible.

Yields

Up to 27 tons per acre from plant crop. With careful pruning, first ratoon should almost equal plant crop. This is equal to 54 tons in 4½-year cycle, which equals 11 tons per year, equal to £100 per year at present cannery prices.

Pruning

After harvest, remove all slips and leave only one (or possibly two) suckers on inside of plant. Excess suckers will result in small fruit. Aim to produce fruit of 4 lb.

Replanting

Better to plant on fresh land but two cycles can be taken on the same land with aid of 12 lb. sulphate of ammonia per 100 plants, i.e. 2 oz. per plant. Apply in four lots at bi-monthly intervals to the soil as close to the plant as possible during moist periods within first year of planting. One heaped teaspoonful = $\frac{1}{2}$ oz. of sulphate of ammonia. Avoid putting sulphate of ammonia on the plants.

Deciduous Fruit Crops

In East Africa temperature is the biggest factor affecting the growth of deciduous fruits. The mean temperature, apart from local variations, decreases as height above sea-level increases.

Altitude, therefore, is a convenient way of indicating in what climates different kinds of fruit are likely to be successful. One local variation which should be noted is the difference in the reaction of fruit trees when planted at the same altitude east or west of the Rift Valley.

As a general rule, a variety which grows successfully at 7,000 ft. east of the Rift should be planted at 8,000 ft. west of the Rift in order to achieve the same result. The recommendations which follow with regard to the altitude at which individual varieties should be planted are for West Rift areas. For East Rift conditions, subtract 1,000 ft. in altitude.

In Southern Tanganyika, which is further from the Equator than Kenya and therefore has a more marked winter, a somewhat larger deduction of altitude may be made.

Unlike the climate in temperate latitudes, there are no very definite seasons in East Africa. There is, however, a slight seasonal variation in temperature without which it would not be possible to grow deciduous fruits. The lack of a more definite summer and winter is an important factor with deciduous fruits, which require a period of low temperatures in winter for their successful growth and a season of relatively high temperatures in summer in order to mature fruit of good quality.

Trees which do not get enough chilling owing to high temperatures during the dormant season, suffer from what is known as "prolonged dormancy". This condition is characterized by a reluctance on the part of the tree to come to life again after the dormant season. The resultant prolonged flowering period causes a poor set of fruit, whilst the small number of leaves is insufficient to shade the fruit and mature it properly.

Districts where mists or overcast skies are prevalent during the dormant season are more favourable for deciduous fruit-growing than those which get more sun.

The adverse effects of warm winters can be overcome to a considerable extent by spraying the trees with D.N.O.C. or tar oil late in the dormant season. The effect of spraying is to cause the buds to open more evenly and at the right time. Although it does not enable varieties to be grown which are right outside their climate, its effect on borderline varieties is almost miraculous.

Spraying at 5 per cent strength every year is recommended as a routine measure for apples, pears, plums, peaches, apricots and nectarines. The time of application is critical: trees do not react if sprayed too early in the dormant season, whilst damage will result if spray is applied after the buds have broken. When spraying, it is important to wet the whole tree thoroughly.

In most parts of East Africa the correct time to spray is as follows:—

Plums, peaches, nectarines, apricots—second half of August.

Apples and pears—first week of September.

At the high altitudes where winter temperatures are low enough for the successful cultivation of deciduous fruits, summer temperatures are also low. The effect on plums and apples is not marked but peaches grown at the higher altitudes are generally of poor quality whilst pears break down in storage and must be consumed fairly quickly.

The wide diurnal range of temperature throughout the Highlands causes a corresponding variation in atmospheric humidity. The intense sun on the fruit in the daytime alternating with dew at night, causes a physiological cracking of the fruit in apricots, certain varieties of apples, and sometimes peaches. Fruit on trees which are short of leaves through prolonged dormancy or other causes is worst affected because it is more exposed.

In Kenya, rainfall is so distributed that the late varieties of fruit are generally short of soil moisture when the crop is maturing. This often has an adverse effect on fruit size and quality and it is worth while to consider irrigating late varieties. In the Southern Highlands of Tanganyika, fruit matures during a rainy period and irrigation should not be necessary. Hailstorms are common in some districts and often do great damage to fruit trees and fruit crops.

APPLES

Most of the early apple orchards were of trees worked on Northern Spy. This rootstock produces a small tree lacking in vigour and producing poor crops. Trees available from nurserymen at present are usually on Cape Seedling or Seedling Crab rootstocks, which are recommended.

With nearly all the varieties grown in East Africa cross-pollination with a suitable variety, that is one which has viable pollen, is essential. The varieties recommended as pollinators are Jonathan and Winter Banana, one or preferably both of which should be included in every orchard in the minimum ratio of one to eight with other varieties.

The correct planting distance for apples is still the subject of experiment. The current recommendation is to space the trees at 10 ft. × 20 ft. or 10 ft. × 15 ft. and remove alternate trees in the row should they become too crowded when they have reached full size.

The varieties recommended are listed in approximate order of ripening. The letters C and D denote varieties suitable for cooking and dessert:—

Sharps' Early. D. 8,000-9,000 ft.—The best early variety. Requires a vigorous rootstock such as Seedling Crab or Crab "C".

Gravenstein. C or D. 7,000-9,000 ft.—Very vigorous, fruit not of the best quality for dessert. Susceptible to Bitter Pit.

Jonathan. D. 7,000-9,000 ft.—Recommended as a pollinator.

Winter Banana. D. 6,500-9,000 ft.—Recommended as a pollinator. Fruit of attractive appearance and fair flavour.

Blenheim Orange. D. 7,000-9,000 ft.—Heavy and early bearer. Susceptible to Bitter Pit.

King of Tomkins County. C or D. 8,000-9,000 ft.—Very vigorous but a light cropper. The fruit is large and of good quality.

Reinette du Canada. C or D. 7,000-9,000 ft.—Similar to King of Tomkins County.

Rome Beauty. D. 6,000-7,000 ft.—Recommended as a pollinator. This variety is of no use at the higher altitudes.

Bramley's Seedling. C. 8,000-9,000 ft.—An excellent culinary apple. The fruit tends to drop before it is mature.

Abundance (*Sherwens*). D. 8,000-9,000 ft.—Perhaps the best quality dessert apple grown in East Africa. Good keeper.

Granny Smith. D. 8,000-9,000 ft.—The fruit has little colour but is of high quality. Rather difficult to grow. Good keeper.

Ballarat Seedling. C or D. 8,000-9,000 ft.—This variety requires a vigorous rootstock. Seedling Crab or Crab "C". The fruit is attractive and keeps very well.

PEARS

Pears take longer to come into bearing than any of the other deciduous fruit. The altitude range is from 7,000 to 9,000 ft. Summer temperatures in this range are high enough to ripen the crop satisfactorily but are too low to mature the fruit to the stage which would enable it to be stored for any length of time.

The rootstock recommended for pears is Wild Pear. Quince stock tends to be too dwarfing under local conditions. Some varieties, such as Keiffer, can be grown successfully from cuttings. Keiffer on its own roots is extremely vigorous; its vigour may be reduced and earlier bearing encouraged by bending down long whippy branches and tying them in an almost horizontal position. The tip of the branch must on no account be below the horizontal and the operation should not be attempted until the trees are well established.

The right time at which to harvest pears is always a difficult problem for the amateur. Most varieties may be picked when the seeds begin to turn brown. Another test is to lift the fruit to the horizontal, if the stem breaks the fruit is ready for picking. These tests are an indication of picking maturity only, most pears will require to be store ripened before they are ready to eat.

The spacing for pears is 10 to 20 ft., and the same remarks apply as for apples. Several varieties should be planted together for cross-pollination, those suitable as pollinators are indicated in the list which follows:—

Jargonelle. 8,000-9,000 ft. — Vigorous grower, will not keep.

Fertility. 8,000-9,000 ft.—Heavy bearer.

Packham's Triumph. 8,000-9,000 ft.—Fairly vigorous and bears well. Fruit of excellent quality.

Keiffer. 7,000-9,000 ft.—The easiest variety to grow. Vigorous and of upright habit which makes it difficult to prune. Fruit suitable for dessert or bottling but not of high quality.

Le Conte. 7,000-9,000 ft.—A good pollinator but fruit of indifferent quality.

Winter Nelis. 8,000-9,000 ft.—A good dessert variety and suitable as a pollinator.

PLUMS

All the plums grown successfully in East Africa are varieties of the Japanese plum (*Prunus salicina, syn. P. triflora*). European plum varieties (*P. domestica*), require a much colder winter and do not thrive under our conditions. Many Japanese plum varieties are well suited to climatic conditions prevailing between 7,000 and 9,000 ft. and are therefore easier to grow than apples and pears. It is, however, important to choose varieties suited to the area in which they are to be grown.

Mariana and Myrobalan are suitable rootstocks for plums. Seedling peach is also used but has the disadvantage of being more susceptible to Crown Gall. Most varieties grow and crop better and the trees are of more uniform vigour if they are grown on their own roots, that is from cuttings. Nurserymen are reluctant to propagate plums from cuttings because it is more trouble than budding. Prospective growers are, however, advised to make every effort to obtain trees on their own roots.

Most varieties are self-unfruitful or partly so; it is important, therefore, to plant several varieties together to ensure adequate cross-pollination and also to extend the cropping season. Planting distance 20-25 ft. The following is a list of recommended varieties in approximate order of ripening:—

Apricot. 7,000-9,000 ft.—A small yellow plum which is excellent for jam.

Methley, Settler and Tazagine. 7,000-9,000 ft.—These three varieties are identical and should be known as Methley type; it is probably the easiest variety to grow. The fruit is dark red and of good flavour, suitable for canning. The trees have a tendency to overbear and the fruit should be thinned.

Wilson. 7,000-9,000 ft.—Fruit rather small, yellow with red cheek.

Beauty. 8,000-9,000 ft.—Large, red dessert plum of similar flavour to Santa Rosa but much earlier.

Jardine's Early. 7,000-9,000 ft.—Fruit rather pale red and usually somewhat larger than Methley. Not suitable for canning.

Hale. 7,000-9,000 ft.—Medium to large size, greenish yellow fruit. Very vigorous.

Shiro. 8,000-9,000 ft.—Large yellow fruit and a heavy cropper.

Santa Rosa. 7,000-9,000 ft.—Popular dessert variety, fruit large, red and of distinctive flavour. Does well east of the Rift Valley but not recommended for planting west of the Rift.

October Purple. 8,000-9,000 ft.—Large red dessert plum of good quality. Ripens late.

Becky Smith. 8,000-9,000 ft.—Large round dessert plum of similar quality to October Purple. Can be stored for three weeks.

QUINCES

The altitude range is from 7,000 to 9,000 ft. but better results may be expected in the upper half of this range. Quinces may be propagated from cuttings and a planting distance of 15 ft. is recommended. Young trees tend to drop their fruit before it is mature but this trouble decreases as the trees grow older. Suitable varieties are as follows:—

Meeche's Prolific; Orange Quince; Portugal; Rae's Mammoth.

PEACHES

Peaches can be grown from 6,000 to 8,000 ft. In the lower part of the altitude range, trouble is experienced with prolonged dormancy and the number of varieties which can be grown is very limited. The optimum range is approximately from 7,000 to 7,500 ft. At higher altitudes, summer temperatures are too low for the production of good quality fruit and Peach Leaf Curl disease is very troublesome.

The rootstock recommended for budded trees is seedling peach. Trees grown from seed will come into bearing at about the same time as budded trees. The spacing for peaches is 20 to 25 ft.

Some very interesting seedling peach types have evolved in the Plateau—Burnt Forest area of Kenya from seed introduced from South Africa by some of the early settlers. Some of these seedlings are now being budded by local nurserymen, whilst many growers raise the trees from seed. Of the named varieties the following are recommended:—

Waldo.—White flesh, freestone.

Shackleford.—White flesh, freestone.

Killiecrankie.—White flesh, freestone.

Alexander Jewel.—White flesh, freestone.

Rousseau Early.—Yellow fleshed freestone, local seedling selection.

Hall's Yellow.—Yellow fleshed clingstone, suitable for canning.

NECTARINES

Nectarines are grown successfully at 8,600 to 9,000 ft. west of the Rift Valley but were unsuccessful at 8,200 ft. It is apparent that the altitude range of this fruit is very limited. The variety Goldmine is recommended, at a spacing of 15-20 ft.

CHERRIES

Cherries, unfortunately, are only a curiosity in East Africa and are not worth growing for the occasional fruit they produce. They should not be planted below 8,000 ft. and should be spaced at 15-20 ft. Morello cherries are perhaps the least difficult to grow.

FIGS

4,000-7,000 ft. For dessert purposes the so-called self-fertile varieties should be grown; the following are recommended:—

White Genoa, Brown Turkey and Green Ischia.

The production of dried figs requires special arrangements for pollinating the flowers which have not so far been attempted in East Africa. If dried figs are required it is much easier to buy them than to attempt production in the home orchard.

Figs require a good supply of soil moisture during the time when the crop is maturing, otherwise the fruit is liable to drop before maturity or to be very dry when ripe. Propagation of figs is by cuttings or suckers, the trees should be spaced at 15-20 ft.

MULBERRY

2,000-7,000 ft. The varieties usually grown in East Africa are probably of *Morus japonica.* The trees are easily grown and a convenient place for them in the home orchard is in the form of a hedge or windbreak along one boundary of the orchard. Propagation is by cuttings and trees may be spaced at 10-20 ft. apart. In order to obtain large fruits, the trees should be pollarded to a height of about 4 ft. every two or three years, and well supplied with water when the crop is maturing.

Three named varieties, Long Bearing, Natalia and Queensland Giant Black, have proved to be very poor croppers and are not recommended. The long-fruited form (fruits up to 6 in.) which is of rather weeping habit, is worth growing.

NUTS

Almonds.—Have been tried quite extensively and on a fairly large scale. Although the trees grow well, crops are most disappointing. After a few years the trees are very liable to die through gummosis and various root diseases. Planting is not recommended.

Chestnuts.—The Spanish chestnut has been grown successfully at between 8,000 and 9,000 ft. The trees grow and bear quite well but the nuts are inclined to be small. Planting distance 30-40 ft. Trees may be raised from seed.

Macadamia or *Queensland Nut.*—This is a handsome evergreen tree bearing spherical nuts in a thick shell: the kernels are of very high quality. The altitude range is approximately 4,000 to 6,500 ft. Plants are raised from seed and trees may be expected to come into bearing in about five years. Planting distance 30 to 40 ft.

Olives.—The European or oil-producing olive grows well in East Africa but does not bear fruit. The reason is that this species requires comparatively low winter temperatures for flowering to be initiated, temperatures considerably lower than occur within the range of cultivation in East Africa.

Pecan Nut.—The Pecan bears a similar nut to the walnut but with a thinner shell. In some parts of the world it is more popular than the walnut. The altitude range in Kenya is approximately 5,000-7,000 ft. The trees require a well-drained soil not less than 10 ft. deep.

River banks with the water-level about 6 ft. from the top of the bank are ideal. Alternatively, trees should be planted under irrigation or in high rainfall areas. Several varieties should be grown together for cross-pollination, the following are recommended:—

Curtis; Schley; Moneymaker; HLH Stuart.

The planting distance is 60 ft. Pecans at this spacing may be interplanted in citrus or other orchards.

Walnuts are very subject to prolonged dormancy in East Africa but have been grown fairly successfully at altitudes between 8,000 and 9,000 ft. Unfortunately, the importation of walnut trees is prohibited for pathological reasons, the prospective grower is therefore restricted to planting seedlings, which are a rather doubtful proposition. The trees should be spaced at 30-60 ft.

GRAPES

The grape vine in East Africa may sometimes be seen growing in rather unexpected situations with apparent success. Fine specimens have been seen in Mombasa, Dar es Salaam and Kisumu. However, vine growing in such climates as these generally could not be recommended.

The normal range of the vine in East Africa is from 6,000 to 7,000 ft. The plants require a moderate amount of winter chilling but, unless temperatures are reasonably high, the crop sets badly and does not ripen well.

Vines should be spaced at 8 ft. between rows and 10 ft. apart in the row; a trellis is required to support the plants. There are literally dozens of different methods of trellising and training vines.

The three-wire T trellis is recommended here because it is simple, inexpensive and has been proved in East Africa. The trellis may be erected after the vines are planted; the uprights which are spaced at 20 ft. apart in the rows of plants, are ordinary fence posts which should project 4 ft. above ground.

A cross piece of 3-in. × 2-in. timber and 2 ft. long is fixed to the top of every post at right angles to the line of the row. A galvanized fencing wire is stapled to each extremity of the cross pieces and a third wire is fixed to the uprights at 18 in. from ground level.

Pruning is carried out when the vines are dormant (July to August), and in the first year after planting should aim at forming the permanent framework of the plant.

This consists of a single stem which branches into two just below the bottom wire of the trellis or two stems may be taken from ground level. The two branches are extended parallel to the ground by tying them to the lower wire and should be cut to a length of 5 ft. to meet with the corresponding branch of the next vine in the row.

From the buds on the horizontal branches, growths will be produced which will develop into the vine's permanent fruiting spurs. The spurs should be spaced at about 9 in. apart along the horizontal branches. The vine bears its crop on new shoots produced every year from the fruiting spurs.

As they grow, these shoots are wound round strings stretched between the lower and two upper wires of the trellis. When the shoots have reached the height of the top wires they are stopped by pinching out the growing point. The stopping has to be repeated several times during the growing season, pinching off not only the terminal shoot but any lateral shoots arising in the axils of the leaves. Thus the plant is trained in the form of a V which allows proper penetration of sun and air.

For production of high quality bunches it is necessary to thin the berries when they are still quite small; this is done by cutting out with scissors all inside and crowded berries. The bunch will appear very thin after this operation but will soon fill out as the berries swell.

After the crop has been harvested and the vines are dormant, the annual pruning is carried out. The year's growth from each spur is cut back to within two buds of its base (short pruning), or in the case of varieties which require long pruning, to within 6-8 buds of the base.

The type of pruning required is indicated in the list of varieties by the letters S or L.

Vines are easily propagated by cuttings and in East Africa this is the most satisfactory method of raising plants. The following varieties are recommended:—

Red Muscadel (S).—Red, berries and bunches small but sweet.

Crystal (L).—White.

Red Hanepoot (L).—Red.

Alphonse Lavallee.—Black, very long bunches.

Golden Muscat (S).—Green, distinctive flavour.

BERRY CROPS

In order to obtain good results with berries, dressings of up to 50 tons per acre of farmyard manure should be applied before planting. Irrigation during the dry season is important because the best crops are produced at this time. Generally berries do better on the heavier soils but drainage must be adequate.

Cape Gooseberry. Sea-level to 9,000 ft.—This is the easiest berry to grow, in fact it has become a weed in many parts of the country. The fruit is excellent stewed or made into jam. Raise from seed and treat as an annual. Plant out seedlings at a spacing of 4 ft. × 2 ft. or 4 ft. × 4 ft.

Currant, Black, Red and White.—None of the currants will succeed in East Africa because they require a long day (more than 12 hours) during the growing season.

Gooseberry.—English gooseberries have been grown more or less successfully at 10,000 ft. on the Aberdares. At lower altitudes they are merely a curiosity and are not worth a place in the fruit garden.

Loganberry.—Under our conditions the fruit is of very poor quality and planting cannot be recommended.

Mora de Castilla (*Rubus glaucus*).—A new introduction from South America. Fruit large and bright red, of distinctive flavour reminiscent of mulberry. The plant does well at 8,000 ft., the lower altitude is not yet known but is probably in the region of 6,000 ft. Space at 5 ft. × 8 ft.

Raspberry. 6,000-9,000 ft.—The European raspberry is not very happy in East Africa and usually bears only light crops. Space the canes at 6 ft. × 2 ft. The growth of suckers is very heavy and should be restricted to a width of 2 ft. in each row by hoeing out all suckers outside this area.

Raspberry, White Stemmed (*Rubus albescens*). 5,000-9,000 ft.—Erroneously known as the "Himalayan Blackberry", a black-fruited species which has become naturalized in some areas. The fruit is of comparatively poor quality owing to its seediness. Space at 5 ft. × 8 ft.

Ra-Strawberry (*Rubus illecebrosus*). 5,000-9,000 ft.—Erroneously known as the "Wineberry". Fruit bright red and of striking appearance but quality poor. Space at 6 ft. × 2 ft. and restrict the sucker growth as for raspberry.

Shanks Blackberry (*Rubus Shankii*).—A new introduction from South America. Fruit large and black with typical blackberry flavour. The plants crop very heavily at 8,000 ft. but the lower altitude limit is not yet known; it is probably in the region of 6,000. Space at 5 ft. × 8 ft.

Strawberry. 5,000-9,000 ft.—The strawberry has no definite season as it has in Europe. Provided sufficient soil moisture is present, plants will flower and crop all the year round. With most varieties, particularly at the higher altitudes, very few or no runners are produced and plants are propagated by division. If cropping is not controlled the plants very soon exhaust themselves and yields are poor.

After planting, all flowers must be removed until the plants have reached mature size. At the higher altitudes, where growth is slow, the deflowering period may last as long as 6-8 months. When the plants are really large and strong, deflowering is stopped and the fruit starts to form.

The harvest period should last for about eight weeks, after which deflowering should be started again and be continued for at least four months before another crop is taken.

By cropping strawberry beds in rotation, fruit can be obtained over a long period but cropping during periods of heavy rain should be avoided. In order to keep the fruit clean and to conserve moisture, the beds should be well mulched with dry grass or straw. Space the plants at 2 ft. × 1 ft.

The following varieties are recommended:—

Cambridge Early Pine.—Heavy cropper, fruit large to medium size, firm and of excellent colour, flavour good.

Cambridge Favourite.—Good cropper, fruit very large to medium size, very firm and of excellent colour, flavour fair.

Melba.—Good cropper, fruit medium size, inclined to be soft, colour fair, flavour indifferent. All of the above are highly resistant to leaf spot (*Mycosphaerella fragariae*).

The variety *Royal Sovereign*, one of the best strawberries ever produced is, unfortunately, not suited to our climate.

Wineberry.—*See* Ra-Strawberry.

Youngberry and Boysenberry. 7,000-9,000 ft.—These are so similar that they may be described together. The Youngberry is probably the best berry fruit which can be grown in East Africa. The fruit is large, dark red, of excellent flavour and not seedy. It is excellent for canning, bottling or for making jam and jelly. It is a heavy cropper.

The plant belongs to the class of trailing berries and should be grown on a 4-ft. trellis of two horizontal wires, spaced at 2 ft. and 4 ft. from the ground. The canes are wound round the wires. Space the plants at 5 ft. and the rows at 8 ft. apart. Full crops should not be expected until the plants are more than two years old.

VEGETABLES

ONION (*Allium Cepa*) Kiswahili—Kitunguu

Varieties

Only short-day varieties can be grown; long-day varieties will not form bulbs in a 12-hour day. Early Cape Flat, Texas Grano, Granex, Hunter River, are short-day varieties which produce heavy yields of large, mild-flavoured bulbs, but their keeping qualities are poor. Bombay Red is the best all-round variety, the bulbs are of medium size, but keeping quality is good.

Climate and Soils

Fairly light, well-drained soils are best. Altitude range is from 2,000 to 9,000 ft., but bulbs produced at the higher altitudes do not ripen or keep well.

Cultivation

Arrange planting dates to ensure a hot, dry period for ripening off the crop. Propagation may be from seed or sets. Seed may be sown in seed beds and the seedlings transplanted to spacing 12 in. × 4 in. when 6 in. high, or seed may be sown direct and the seedlings thinned to the same spacing. For transplanting, 2 lb. seed required per acre, double the quantity for direct sowing. Avoid deep planting of seedlings. Frequent weeding is essential, and the soil should always be drawn away from the bulbs, so that at harvesting time only the roots are below soil level.

Harvesting

It is not necessary to twist the necks of onions. Bulbs should be lifted and dried off in wind rows in the open (3-10 days), when the necks of the bulbs become thin and soft, but whilst the leaves are still green. When dry, hang in strings or lay on the floor of a dry store in a thin layer. Pack in 50-lb. open-mesh bags just before marketing. Yield of large-bulbed varieties 7-12 tons per acre. Bombay Red 5-7 tons per acre.

Major Uses

For eating fresh and cooked, pickles, flavouring.

ASPARAGUS (*Asparagus officinalis*)

Varieties

Mary Washington or Strain 500.

Climate and Soils

May be grown in any climate, but yields are probably higher in the middle range of altitudes. Soils should be reasonably light, deep, and well drained. On heavy and stony soils many spears will be deformed.

Cultivation

Maturity is reached in three years from seed. Locally collected seed should never be used; about 5 lb. of seed required to produce crowns to plant 1 acre. Sow seed in nusery, 1 in. deep in rows 2 ft. apart, space seeds 4 in. apart in row. After 1 year the young crowns are ready to plant out. Discard all small or poorly-rooted crowns (discards may be as high as 75 per cent). Prepare soil by deep ploughing or digging, then plough or dig a trench 9 in. deep for each row, 7 ft. apart. Place crowns in the bottom of the trench at 1 ft. apart, fill with soil and firm. The establishment period is two years, after planting out. The life of a planting is 10 to 15 years.

Harvesting

The first cutting season, at the end of the two-year establishment period, should be of three weeks duration only, subsequent cutting seasons are of eight weeks duration. A field is normally cut only once annually, but the harvest may be extended, in most districts, over about six months, by cutting different plots in rotation. The harvest season is initiated by cutting back the fern to ground level, and earthing up the rows. The first spears appear a few days after cutting back the fern. During the harvest period *all* spears must be cut; if some are left, production falls off. Spears are cut to a length of 9-10 in., with a special knife or large carpenters chisel; this is thrust through the soil and the cut is made below soil level. For blanched asparagus, cut as soon as spears appear above soil level; for green, allow spears to grow 3-4 in. before cutting. Handle spears with care, they bruise easily, and avoid drying out. Wash off soil, and trim spears to 8 in. long; grade for size, tie in 1-lb. bundles, and pack each bundle in a perforated plastic tube. Pack in wooden containers holding 12-14 lb. Yield, 1,500-2,000 lb. per acre (untrimmed). Between harvests all the fern must be allowed to grow; unless there is a good growth of fern the succeeding crop will be poor.

Major Uses

For eating cooked, and for canning.

BRASSICAS

There are several varieties of cabbages, but the more important commercial varieties are listed as follows:—

Earlies.—Copenhagen Market and Early Charleston.

Mid Season.—Dutch Flat and Winningstadt.

Lates.—Savoy Drumhead and Late Flat Dutch.

Cauliflowers are a good commercial proposition, but there are very few varieties suited to our climatic conditions, those that have proved worth while are Super Snowball and Mauritius.

Brussels sprouts also have good commercial value, but require a comparatively cool climate for the sprouts to become firm, small yields are recorded in this country, but the more promising varieties are Fill Basket and Covent Garden.

Cultivation and Soil

All Brassicas thrive on most soil types of reasonably good fertility and moisture. They are gross feeders and take a good deal out of the soil, it is therefore essential that manure and fertilizers are applied liberally. Generally speaking, early types of cabbages require a sandy loam that holds moisture and yet has good drainage. Mid season and late varieties need heavier and cooler soils. If Brassicas are sown in a nursery bed and then transplanted, about ¼ lb. of seed is required, but if sown direct in drills and then thinned, 1-2 lb. Cabbages are adapted to a wide range of climates, from 2,500-9,000 ft., but cauliflowers and Brussels sprouts are limited from 5,000-8,000 ft. It is essential that if cauliflowers are sown in a nursery bed they are transplanted as soon as possible, otherwise they fail to "button".

Harvesting

Cabbages are harvested when the heads are as hard and heavy as they will become without bursting, generally 4-7 wrapper leaves are left attached to the head. They should be marketed in 50-lb. open-mesh sacks.

Cauliflowers should be cut slightly early rather than late, before they become "ricey", or discoloured. A few leaves should be left around the head and cut between 1-2 in. above it to act as a protection. They should be handled with care and marketed in wooden crates 14 in. × 12 in. × 22 in. to arrive in a fresh, pure white condition.

Brussels sprouts are ready for harvest when the heads develop like small firm cabbages, and are generally marketed in 25-lb. open-mesh sacks.

Major Uses

Cabbages.—Salads, boiling, pickling and sauerkraut.

Cauliflower.—As a vegetable, in pickles and savoury dishes.

Brussels Sprouts.—Boiling and pickling.

ROOT CROPS

Commercial varieties:—

(*a*) *Carrot.*—Oxheart types, Nantes types and Chantenay.

(*b*) *Beetroot.*—Flat Egyptian, and Detroit Dark Red.

(*c*) *Parsnip.*—Crown Rounded, and Hollow Crown.

(*d*) *Turnip.*—Purple Top Milon and Snowball.

Cultivation and Soil

The soil type for all root crops should be deep, fertile and well-drained sandy loam, or a soil with a good open texture so that the roots can penetrate and develop evenly without a check, this applies particularly to carrots and parsnips. Heavy applications of manure are not necessary, and root crops should follow brassicas in rotation because of the residual effect. Cultural limits are from 300-9,000 ft. All root crops should be sown direct.

Harvesting

Carrots can be thinned before they are fully mature and graded into the following sizes: ¾-1½ in. diameter 8-12 per bunch; 1-1½ in. diameter, 6-8 per bunch. It is not necessary to thin at an early stage, all thinnings can be sold; ¾-1 in. diameter are the first thinnings. The crop is marketed in 50-lb. open-mesh sacks. Most beetroot varieties are ready for harvesting when 1¼-1½ in. diameter and they should preferably be packed in lettuce crates because they bruise easily, or 25-lb. open-mesh sacks. Parsnips are pulled when young and sold in bunches with the tops on, about 6-8 per bunch. Care must be taken when harvesting the main crop as the roots are very long and it is desirable that these should not be broken. It is best to market them in lettuce crates, or 50-lb. open-mesh sacks. Turnips should be harvested when 2-3 in. diameter, the tops should be cut and the roots trimmed and packed in 50-lb. open-mesh sacks.

Major Uses

Carrots.—Canned products, fresh vegetable or boiled.

Beetroot.—Canning and salads.

Parsnip.—Boiled vegetable and parsnip wine.

Turnip.—Boiled vegetable.

LEGUMES

Peas.—Onward, and Kelvedon Wonder, Greenfeast.

Dwarf Beans.—Canadian Wonder and Tender Green (stringless).

Broad Beans.—Sutton's Emerald Longpod and American Fillbasket.

Lima Beans.—Ventura and Early market.

Cultivation

All legume seeds are sown direct and the soil type should be a sandy loam which results in early cropping. Avoid acid and infertile soils where possible, but this can be overcome by inoculation which is likely to increase yields and improve the grade of legumes. Alkaline and fertile soils retain the desirable nodule bacteria more effectively. Most legumes are gross feeders but have nitrogen fixing capabilities and therefore brassicas should follow a legume crop. Heavy applications of manure are not necessary, and when the legume crop is finished the pea vines or beanstalks should not be dug in if they are carrying diseases, but fed to cattle or composted. Cultural limits for peas and broad beans are from 5,000-9,000 ft. for dwarf and Lima beans from 3,500-9,000 ft. Peas and broad beans require cool, moist conditions in which to mature properly. It is not economical to stake peas or lima beans, but if grown at the spacing suggested, they will support each other.

Harvesting

Peas must be harvested at the proper stage of maturity and used or marketed as soon as possible because they lose quality rapidly and careful hand picking is essential. They should be packed in 50-lb. open-mesh sacks, *not* 200-lb bags. Dwarf and Lima beans can be picked before full maturity for the fresh market or left until the beans in the pods are hard and then threshed and sold as dry beans. Green beans are packed in 50-lb. open-mesh bags but dry beans are packed in 200-lb. sacks. Broad beans are harvested when the bean inside the pod is neither too hard nor too immature, they are generally packed in 50-lb. open-mesh sacks.

Major Uses

Peas.—Canned products, boiled, and salads.

Dwarf Beans.—Boiled fresh vegetable, dried bean, and canning.

Broad Beans.—Canned, boiled fresh vegetable.

Lima Beans.—Mainly used as a dry bean and for canning.

SALADS

Lettuce.—New York Special, Iceberg, Mignonette (low altitude variety).

Celery.—Any of the self-blanching varieties.

Cultivation and Soil.

All salad crops require rich, fertile, friable textured soils. Those which do not hold moisture are undesirable, but avoid waterlogged soils. Applications of well-rotted moisture-holding muck are essential. Although salads are sensitive to high acidity it is very rarely that lime has to be applied. Do not grow salad crops on the same ground twice and never grow lettuce and celery together or following one another. If the soil acidity is too high consult the Chief Soil Chemist as to the rate of lime to apply, because heavy dressings may bring the soil reaction down to neutral, in which case chlorosis develops severely. Cultural limits are between 0-9,000 ft.

for lettuce and from 6,000-9,000 ft. for celery which prefers a long growing season. Celery is sown in a nursery seed-bed and then transplanted in a trench 1 ft. wide by 4-6 in. deep with well-rotted manure forked into the trench; as the plants grow they are earthed up. Lettuces can either be sown direct and then thinned or sown in a seed-bed and transplanted.

Harvesting

Lettuces are harvested when the heads are well formed and firm; any with split heads or "tip burn" are worthless. Do not cut immediately after rain or while dew is on the crop: allow to dry a little as when leaves are wet and brittle they are easily broken. It is also a common fault to pack lettuces wet, causing considerable damage in transit by the lettuces overheating and rotting. Outside leaves should be trimmed to the minimum and when packing in crates the bottom layer of lettuces are packed with heads facing upwards and the top layer with the stalk end up. A crate will hold from 4-6 doz. heads. Celery is cut 1-2 in. below the root system and after being cut is trimmed. Celery should not be left in the sun as it is susceptible to sun scorch and wilting; after removal from the field it should be washed before marketing. It is generally packed in crates 9¾ in. × 16 in. × 20 in.

Major Uses

Lettuce.—Fresh salads.

Celery.—Eaten fresh, soups, puree, fried, spiced and as a relish with cheese.

Cucurbits

Pumpkin.—Marblehead and Baby Blue.

Cucumber.—Hybrid Saladeer, and Hybrid Superslicer.

Melon (Cantaloupe).—Texas M.R. No. 1 and Imperial No. 6.

Melon (Water Melon).—Blue Klondike Ribbon and Fairfax W.R.

Cultivation and Soil

Any soil which is fairly fertile and not too acid; avoid waterlogged soils. Light, sandy loams give the best results if manure is applied liberally. Most cucurbits do best on a ridge especially if irrigation is available, they will not tolerate "wet feet" which also encourages mildew. Seed is sown direct, 4-5 seeds per planting distance and thinned to one when two true leaves appear. It is advisable to take off all flowers until the plants can support the fruits, i.e. 4 ft. long; after this period a fortnightly spray programme should be carried out using one part Malathion to eight parts molasses to 64 parts water: this should control fruit fly and red spider mite. As most cucurbits trail on the ground it is advisable to mulch with grass to prevent the fruits from spoiling. Cultural limits are from 0-6,000 ft.

Harvesting

When harvesting cucurbits a short piece of stem should be left on each fruit; avoid injury to the vines when picking. It is extremely difficult to know when to harvest water and cantaloupe melons. Some of the indications are as follows:—

(1) Softening of the shell at the blossom end.

(2) Change of colour of the base of the pedicle from green to orange.

(3) Cracking about the stem.

(4) Aroma.

(5) By cutting an occasional fruit.

Due to the fact that prices for pumpkin, cucumber and water melons are low it is advisable to pack in 50-lb. open-mesh sacks, but with cantaloupe melons prices are high and flat trays 4 in. × 12 in. × 22⅛ in. should be used.

Major Uses

Pumpkin.—Pickle, jam and as a vegetable.

Cucumber.—Salads and pickled.

Melon (Cantaloupe).—Dessert.

Melon (Water).—Jam and dessert.

PRELIMINARY TRIALS OF GRASSES AND LEGUMES UNDER GRAZING

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Since the Grassland Research Station was founded at Kitale in 1950, many hundreds of grasses and legumes have been studied with a view to selecting the best for possible future introduction into agricultural use. Observations on some of these have already been made by Bogdan (1955) and Strange (1955), and the work which is summarized here is to some extent a sequel to that described in these two papers.

Kitale lies 1° N. of the Equator north-east from Lake Victoria at an altitude of 6,200 ft. The mean rainfall is 46 in., falling mainly between April and October, with a drought period (hot season) from December to March. The soil is a friable sandy loam of rather low fertility which is derived from the Basement Complex. It varies in colour from red to grey and generally has a pH of between 5 and 6.

The selection of species and strains follows a well-defined routine, viz.—

(i) the introduction of grasses and legumes into the nursery from sources within and without East Africa;

(ii) preliminary grazing trials or "first rotation" experiments, using some of the more promising species from the nursery;

(iii) further grazing trials or "second rotation" experiments, using a few of the more satisfactory types on larger plots;

(iv) the use on a farm scale, or "main rotation", of those species which have successfully withstood the earlier tests.

The results which are reported in this paper were obtained from the three earliest "first rotation" trials, which were started in 1952, 1953 and 1954 respectively. The 1952 and 1953 trials have been continued for four complete seasons, and the 1954 trial for three seasons only. The plants have been assessed on their productivity, their leafiness and palatability, and their ability to withstand periods of relative dryness or drought. Triple superphosphates and sulphate of ammonia were applied at varying rates and the swards were managed under a system of rotational grazing which was roughly akin to normal farming practice. All the legumes were sown in mixture with either Rhodes or molasses grass.

It has now become clear, however, that some of the techniques which were used in these trials were unsatisfactory. For example, the importance of legume inoculation was not sufficiently appreciated and indeed, in 1952, none of the legumes was inoculated before planting. In the later trials many of the legumes gave disappointing results despite the fact that they had been inoculated and it appears that this may have been due to a sulphur shortage in our soils, of which we were unaware at the time; as in some recent experiments legume growth has been much stimulated by the application of gypsum or calcium sulphate. Furthermore, the management on a part of our 1952 trial was to graze frequently followed by close mowing, and this has subsequently been found to be unsatisfactory for a number of species, which lose much of their productivity and persistence under such treatment.

The account which follows has been written in the light of the more recent knowledge that has become available and, in assessing the performance of these species under grazing, some allowance has been made for the shortcomings in our earlier techniques.

Where a number of strains of a species have been compared, the best of them is mentioned if obvious differences have shown up.

GRASSES

Andropogon schinzii: this Kenya perennial did not establish well from seed, and was neither productive nor persistent when grazed.

Beckeropsis uniseta: Natal grass, or Beck grass, occurs quite commonly in some of the high rainfall areas of Kenya at altitudes of between 5,000 to 7,000 ft. It was quite productive and leafy, and persisted for four seasons, but was not very drought-resistant. It is an excellent seeder, being quick and easy to establish, and grazing trials are continuing.

Bothriochloa insculpta: known as Sweet Pitted grass, is an indigenous perennial which is very hardy and persistent, and which forms a good sward. It was productive and palatable, but inclines to stemminess and does not appear to be among the best ley grasses for high rainfall conditions owing to this tendency to lose its quality rather rapidly. It is strongly recommended for testing in low rainfall areas, however, and more especially on black cotton soils, where it often thrives naturally. Harvesting and handling the seed may be difficult owing to the fluffiness of the seed heads.

Bothriochloa ischaemum: the "King ranch" strain of Turkestan Bluestem was used in this trial. It is strongly persistent but is unsatisfactory owing to its relatively low yield and extremely prostrate growth which makes it unsuitable for grazing by cattle.

Brachiaria brizantha: Signal grass is an indigenous tufted perennial of diverse type, but often rather stemmy and erect. The best forms in these trials were quite productive, palatable, persistent and drought-resistant; but its seeding qualities are poor, and unless this can be overcome it is unlikely to become important for sown pastures. It is probably less satisfactory for grazing mixtures than the best strains of *B. ruziziensis* (described below) as, being more tufted and erect, it does not form such a good cover.

Brachiaria decumbens is a Kenya perennial which made very prostrate growth and was highly stoloniferous and persistent, but rather lacking in vigour. It seems to be inferior to *B. ruziziensis* and is probably not worth further trial, particularly in view of its poor seed production.

Brachiaria nigropedata, an indigenous perennial, gave poor production and was generally unsatisfactory.

Brachiaria ruziziensis, or Signal grass, is a leafy perennial species which made prostrate growth, producing long stems which rooted to some extent from the nodes. The best forms appear to be very satisfactory for grazing leys, but the ones tried so far have the disadvantage of being poor seeders. If this difficulty can be overcome it may prove to be a valuable grass in many of the medium altitude areas of Kenya. The strain K.52320 is worth special mention.

Until recently this species has not been distinguished from *B. brizantha* and was described by Bogdan (1) as a prostrate form of *B. brizantha*.

Brachiaria soluta was very persistent and quite productive but of poor quality and low palatability, therefore not worth further trial. It is common in many of the medium altitude high rainfall areas of Kenya.

Bromus inermis, Smooth Brome grass, gave poor production and did not persist for much more than a season. It is not suitable for these conditions but is probably worth trial in high rainfall areas at altitudes over 8,000 ft.

Cenchrus ciliaris, commonly known as African foxtail or Buffel grass, is a variable species which does not compare very favourably with the best pasture grasses under high rainfall conditions, even though some forms in these trials were persistent, palatable, and drought-resistant. It has already been proved to be of value for the lower rainfall districts where it undoubtedly flourishes, however, and deserves careful trial in such areas as Machakos and the Athi plains. The harvesting of seed may present some difficulties owing to the long hairy bristles on the seed heads, although once the seed has been gathered these can be removed by hammer milling.

Chloris gayana: Rhodes grass is probably the most important general purpose ley grass for use in the medium altitude mixed farming areas of this country, the best strains giving good grazing or hay during the rains and early in the dry weather. Of the strains observed in these trials, Nzoia, Rongai, Alego and Endebess deserve special mention. There are numerous varieties in existence in South, East, Central and West Africa, and work on the selection of improved types is continuing.

Cymbopogon afronardus: this perennial species, which is known locally as Ulengi, or Blue citronella grass, was productive, persistent and drought-resistant, but coarse and almost entirely unpalatable. It is therefore unsuitable as a pasture species, but has the merit of being an excellent thatching grass.

Cymbopogon giganteum: giant turpentine grass, was persistent, productive and remarkably drought-resistant. Its quality appears to be good, and it is moderately well grazed in spite of possessing an aromatic flavour. It may be worth small scale trial for grazing during the drier months in some of the low rainfall districts of the Kenya Highlands. Poor seed production may be a limiting factor in its use.

Cynodon dactylon: common star grass, while not amongst the heaviest yielders except where soil fertility is high, is generally of better quality than most of our indigenous grasses. It certainly merits intensive trial in view of its widespread occurrence and importance in some localities, where its chief value may be for long-term leys or permanent pasture on land of high fertility. It may prove to be especially useful for late season reserve grazing as it is comparatively drought-resistant and does not lose its quality as rapidly as many other grasses. In these trials the medium forms have been superior to the very coarse and very fine types.

Cynodon plectostachyus or Naivasha Star grass was satisfactory for one or two seasons only under the Kitale conditions, as it does not appear to thrive in areas of high humidity, and did not persist when intensively grazed. Further trial at Kitale may not be justified, but it should undoubtedly be tested in sown pastures on the more fertile soils in low rainfall areas. Some strains produce good seed crops in areas of low humidity.

Dactylis glomerata, which is commonly known as Cocksfoot or Orchard grass, is not sufficiently hardy for these medium altitude conditions and, when grazed, gave a poor performance compared with many other species. Although it proved unsatisfactory in these trials, it does well at altitudes over 8,000 ft. in the high rainfall areas where it is now being used extensively.

Digitaria gazensis: this indigenous perennial, which has been named Gaza Finger grass, makes rather short tufted growth, and established poorly from seed in these trials. It gave low production with poor persistence, and is unsatisfactory.

Digitaria smutsii is a South African perennial which made poor establishment and growth, and proved to be unsatisfactory.

Enteropogon macrostachyus, or Bush rye, persisted well for about two seasons and is productive, palatable, quick to recover after grazing, and a good seeder. It is not equal to the best temporary ley grasses under these conditions as it is out of its natural habitat, but it deserves trial in warmer areas of Kenya with lower rainfall such as Ukamba District, Kitui, and parts of W. Suk, where it occurs quite commonly.

Eragrostis caespitosa, Cushion lovegrass, made poor establishment and growth at Kitale but is possibly worth trial for reseeding some of the semi-arid grazing areas of East Africa as it is more at home under those conditions.

Eragrostis chloromelas, or Boer lovegrass, is a hardy and productive South African perennial, but is fibrous and rather unpalatable. It probably only warrants further attention in some of the semi-arid areas of this country, if at all.

Eragrostis curvula, known also as Weeping lovegrass, is similar to *E. chloromelas* but is rather less coarse. It is quite popular as a ley grass in some of the lower rainfall, mixed farming areas of South Africa.

Eragrostis lehmanniana, or Lehmann's lovegrass, is a low quality species which made poor growth and was generally unsatisfactory.

Eragrostis superba: Masai lovegrass, which is common in many of the drier parts of Kenya, showed good persistence and fair productivity under grazing, but was inclined to stemminess. It is inferior to the best grasses for the relatively high rainfall conditions at Kitale, but has distinct possibilities for temporary leys or for the re-seeding of denuded grazing land in some of the semi-arid districts of this country.

Festuca elatior: the American strain of Tall Fescue known as Kentucky Fescue showed itself to be insufficiently productive and drought-resistant for these conditions, but it does well in some areas of Kenya at altitudes over about 8,000 ft., where it deserves further trial.

Hyparrhenia cymbaria comprises many local forms which vary considerably but which are generally erect, with short stolons. Those which were included in these trials showed good persistence, but were of medium productivity and quality, and tended to develop strong woody stems. Their seeding qualities are generally poor, and on the whole these grasses are unsatisfactory.

Hyparrhenia lintonii is a rather low growing tufted grass which was persistent and quite productive, but which is stemmy and of low palatability at the later stages of growth. It appears to have fair seeding qualities but hardly merits further attention for use in sown pastures.

Hyparrhenia papillipes was unsatisfactory as, although highly drought-resistant and quite productive, it is very fibrous and unpalatable.

Hyparrhenia sp. nr. hirta: this local grass was persistent, hardy, and highly productive when grazed, but is rather fibrous and not very palatable. It may be worth further trial in other areas on low fertility land and in a lower rainfall, especially if suitable techniques can be developed for harvesting and handling the seed, as this will probably present some difficulty. Strain K.50192 has done well.

Lolium italicum: with careful management Italian rye grass gave a good yield of high quality herbage for two seasons, and appears to have possibilities at Kitale for undersowing in cereals to provide a special one-year ley on fertile land, probably within the arable break. This is to be the subject of further trials. It is already being used extensively at higher altitudes.

Melinis minutiflora, or molasses grass, gave a good all-round performance under grazing, generally persisting well for four seasons. Of the strains observed, the Kitale commercial and Chania River types were among the best. There are several indigenous strains of this grass which occur in parts of the Kenya Highlands below about 8,000 ft.

Molasses grass has been in use for a number of years in the Trans Nzoia District, and in other medium altitude, mixed farming areas. Although it tends to be of rather poor quality, it is a good seeder, easy to establish, and a good yielder.

Panicum antidotale, or Blue Panic grass, seed of which was imported from U.S.A., made poor growth and did not withstand grazing. It is not worth further trial under these conditions.

Panicum coloratum, which has been named coloured Guinea or Keria grass, is a promising indigenous perennial for use in general purpose leys. The best strains established easily, gave a quick production of high quality feed, and persisted for three seasons under intensive grazing. It is definitely worth further trial for short-term leys in these conditions, and also in areas of lower rainfall, where it often occurs naturally in localities which are subject to seasonal waterlogging. Strain K.52490 has done particularly well.

Panicum coloratum var. makarikariensis: Makarikari grass from South Africa proved to be persistent, palatable and highly drought-resistant, but gave a rather low yield. It has poor seeding qualities although certain strains which were not included in this trial are better in this respect. It is not worth further trial at Kitale, but deserves further attention in lower rainfall areas, provided that good seeding strains are used.

Panicum maximum: many strains of Guinea grass occur naturally in East Africa, the best of which are productive, palatable, and persistent under grazing if carefully managed. Guinea grass is drought-resistant and is therefore potentially valuable for reserve grazing during periods of relatively dry weather. Some forms possess fair seeding qualities. The Sigor strain K.52530 has done well in these trials. More recent work at Kitale has confirmed its productivity and its suitability for late season grazing, and it is very probable that, as in other parts of the tropics, selected strains will come into commercial use.

Panicum maximum var. trichoglume, or slender Guinea grass, has somewhat finer leaves and stems and appeared to be slightly less productive than the best *Panicum maximum* strains. It is a better seeder and more easy to establish than most of the other Guinea grasses, however, and may therefore become important as a general purpose ley species as well as providing useful late-season reserve grazing.

Paspalum dilatatum is a South American Species which is known in U.S.A. as Dallis grass. It formed a persistent, dense, low growing sward when grazed, but gave a relatively low yield and was not very palatable. It is a rather poor seeder under these conditions and seems unlikely to become important, except possibly for use on limited areas of poorly drained land at altitudes over 7,000 ft.

Paspalum malacophyllum is another grass of South American origin which proved to be persistent under grazing, but which is possibly also a rather low yielder in these conditions, compared with some other species such as *Chloris gayana.* It forms a dense leafy sward and is being tested further both at Kitale and at higher altitudes. It has the advantage of being a fair seeder.

Paspalum scrobiculatum var. commersonii: this widely occurring Kenya perennial, which has been named Ditch millet, has persisted well under grazing and is productive and of attractive quality. It is a good seeder and well worth further trial, perhaps more especially for use in mixture with other grasses, or for sowing on medium or low fertility land where it often comes in naturally as a pioneer.

Paspalum urvillei: this tufted grass, of American origin, established badly and gave low yields when grazed. It appears to have rather poor seeding qualities, and is not worth further trial under these conditions except perhaps for use in wet "vlei" land where it is said to do quite well.

Pennisetum glabrum is an indigenous grass which, although tufted, also forms short rhizomes. It is poor in almost every respect and it is not worth further trial.

Pennisetum polystachyon, which occurs in some of the drier areas of East Africa, appears to vary considerably in its growth and persistence. The best strain in these trials, K.53176, is persistent, productive and palatable, although rather inclined to be stemmy. It is a fair seeder, but the long hairy bristles may give rise to some difficulty in handling the seed, although the seed can easily be beaten out from the spikelets. It merits further trial in some of the lower rainfall areas where it may prove useful for re-seeding denuded grazing land.

Pennisetum purpureum: Elephant grass or Napier grass, which originates in Equatorial Africa, persists for at least four years and will withstand quite frequent grazing if carefully managed. It is strongly drought-resistant and a heavy yielder of medium quality herbage; useful primarily for grazing late in the rains and during the dry season when other grasses are becoming dormant. The following four strains were compared: Gold Coast, Cameroons, Uganda hairless, and a common form used locally on many farms. The Gold Coast and Cameroons strains withstood grazing better than the others, and were the most productive, the former being possibly the more palatable of the two.

Pennisetum stramineum is a rhizomatous grass which was persistent and quite productive, but which rapidly formed hard stems and became unpalatable unless kept well grazed down. It is unsatisfactory for sown pastures, although it is one of the more important species in some of the grasslands of the low rainfall ranching districts.

Pennisetum trachyphyllum: this short-lived stoloniferous species did not withstand intensive grazing. It remained leafy and productive for one or two seasons only, and probably requires a high level of fertility in order to persist. It has rather poor seeding qualities and is not worth further trial.

Phalaris tuberosa, or Canary grass, is persistent and leafy during the wet weather, but appeared to yield rather less than some other species in these trials. It showed poor drought resistance, drying up rapidly at the end of the rains. However, it is undoubtedly worth trial on fertile soils and at higher altitudes where, in fact, it is already being used to some extent. It appears to tolerate quite a high degree of seasonal waterlogging.

Rhynchelytrum subglabrum is a drought-resistant species which occurs naturally in low rainfall conditions, but further trial is hardly warranted in view of its low yield and rather poor quality.

Setaria longiseta: the local forms of this grass are very variable but are generally satisfactory under grazing. It established well and was persistent and gave a fair yield. It has good seeding qualities, and some work on the selection of leafy strains appears to be justified.

Setaria sphacelata: the best local strain, Nandi setaria, is persistent, productive, palatable, and of fair quality. The other forms in these trials were fibrous and harsh. It is quite a good seeder, but is generally not quite as good as Rhodes or molasses grass in that respect, being highly susceptible to the "Covered smut" or "Bunt" disease which can cause severe loss of seed. Nandi setaria is now being used to some extent in general purpose leys, and is doing well on land of medium to high fertility, also on some poorly drained "vlei" soils.

Setaria splendida is a vigorous tufted grass, the forms of which are rather variable. It is very productive, palatable and of good quality and, although a poor seeder, it is easy to establish vegetatively. Given careful management its persists well under grazing and therefore warrants further trial, especially for use late in the rains and during the early part of the dry season. It would provide useful ensilage material from the early flush.

A number of clones were compared in these trials, K.53768 being one of the best.

Setaria trinervia, which occurs locally near Kitale, proved to be inferior to Nandi setaria and is not worth further trial for sowing in temporary leys.

Snowdenia polystachya is an extremely variable annual or short-lived perennial species which was introduced from Ethiopia. It was quite vigorous and productive for about a season, and an excellent seeder, but is not worth further trial owing to its lack of persistence and low productivity after the first year. It has become a serious weed of arable land in the Ol Kalou area of Kenya, between 7,000 and 8,000 ft., where it is known by farmers as "Beckeropsis".

Sporobolus filipes: this indigenous grass was persistent and quite productive under grazing but is rather unpalatable and of doubtful quality, as it runs rapidly to stem. It is a very good seeder, but further trial appears to be unjustified as, apart from its other faults, it is too slow in establishment.

Urochloa bolbodes, which occurs in some of the drier areas of the Colony, established poorly from seed and gave low yields, with poor persistence under grazing. It is not worth further trial.

Urochloa pullulans: The comments on *U. bolbodes* also apply to this grass.

Urochloa sp. nr. trichopus: The comments on *U. bolbodes* also apply to this grass.

LEGUMES

Alysicarpus rugosus subsp. perennirufus, or Kenya Alyce Clover, was known locally as *Alysicarpus glumaceous* until recently. Establishment from seed is slow and rather unreliable, but the plant is palatable and certain forms persist well under grazing. Its yield and quality appear to be lower than that of Kenya white clover, and it does not warrant further trial at present.

Antopetitia abyssinica: this annual plant, which is common in the Kitale vicinity, is quite productive and palatable but will not regenerate freely from seed unless carefully managed. It was inferior to the better annuals and will probably not be tried again.

Argyrolobium keniense is a small erect woody perennial, which is unsatisfactory for grazed pastures.

Argyrolobium leucophyllum: this erect woody perennial was unpalatable and of poor quality.

Astragalus abyssinicus is a coarse and unpalatable annual which did not persist when grazed, and is therefore unsatisfactory.

Astragalus somalensis is an indigenous perennial herb which is erect and woody, and which proved to be unpalatable and unsatisfactory for grazed pastures.

Astragalus venosus: this perennial legume, which occurs naturally in local grassland, gave a fair yield but was rather unpalatable, although apparently its quality is high. It is not sufficiently persistent under grazing, however, and further trials have therefore been discontinued.

Centrosema pubescens, a South American vine which is commonly known as Centro, was slow to establish and made poor growth with poor persistence under grazing. It is suitable for trial in more tropical conditions such as those at the Coast.

Clitoria ternatea, or Kordofan pea, is an indigenous perennial which was slow to establish and made poor growth, particularly during the rainy season. It will not tolerate a high humidity, but has considerable possibilities for use in some of the lower rainfall, mixed farming areas. For example, it is now doing well in pasture trials on red soil in the Ukamba District, and may also do well as a grazing legume on "black cotton soils", where it often grows naturally.

Crotalaria greenwayii is an indigenous bushy short-lived herb which is unsuitable for use in grazing leys.

Crotalaria incana: this plant was vigorous and quick to grow from seed, but is of rather poor quality and medium to low palatability. Being rather woody and erect, it is unsuitable for grazing leys but may be worth further trial for green manuring.

Crotalaria intermedia was also quite productive and quick growing, but is unsuitable for grazed pastures. It is generally of low palatability, although an exception is strain K.5120, which is palatable and has possibilities as a forage catch crop or for green manure. This form is sometimes grown by Africans as a vegetable.

Crotalaria lachnocarpoides is a woody perennial shrub which proved to be poor in nearly all respects.

Dolichos biflorus Avett non L., known commonly as Horsegram, is vigorous, drought-resistant, persistent and a good seeder, but unfortunately it has proved to be of low palatability. Its vigour and dry season greenness favour it for use in special late-season grazing mixtures, but further trial will be necessary to check on its palatability.

Dolichos falcatus was moderately productive, palatable and persistent under grazing, but is not equal to the best of the twining legumes.

It has fair seeding qualities if supported from the ground, but the seed is difficult to harvest. Trials may continue at Kitale on a limited scale.

Dolichos formosus was poor in most respects and will not be continued with at Kitale. It is a perennial twiner.

Dolichos sp. nr. D. formosus has been called Kilima Kiu Dolichos, and is a drought-resistant twiner which, although vigorous, is not sufficiently persistent under repeated grazing for use in general purpose pastures. It may be satisfactory for special late-season mixtures, but has the great disadvantage of being a very shy seeder. It therefore only merits further trial on a limited scale, if at all.

Dolichos lablab (correctly *Lablab niger* Medic.) which is variously known as Njahi bean, Fiwi bean, Vi-vi bean, or Hyacinth bean, is a semi-erect bushy plant which, although persisting for more than a season if undisturbed, should normally be regarded as an annual for agricultural purposes. Its chief use will be as a forage or seed crop within the arable break, and in this capacity it has shown itself to be capable of giving satisfactory yields of green material or beans. The flowers are susceptible to beetle attack, and some control measures may be necessary. There are many strains, some of which are vigorous climbers.

Dolichos sp. nr. D. lablab is a vigorous perennial twiner which occurs locally and which is one of the more promising legumes for use in special late-season grazing mixtures with Guinea grass. It was vigorous and drought-resistant, and is a good seeder.

Eriosema elliottii: this hardy indigenous herd was persistent under grazing but gave a low yield and was relatively unpalatable. It is rather a poor seeder and is not worth further trial.

Eriosema richardii is a Kenya perennial which makes semi-erect bushy growth, having woody stems and an unsatisfactory form for grazing. It gave a fair yield and was quite palatable and persistent, but appears to have rather poor seeding qualities. It will not be tried again at present in sown pastures at Kitale.

Glycine javanica occurs quite commonly in many parts of the Kenya Highlands and has a number of points to recommend it for further trial in grazing mixtures. It is vigorous, drought-resistant, and persistent, as well as being a good producer of seed. It may do well in late-season leys with Guinea grass, and is now being tried for that purpose. Strains K.50194, K.50101 and K.51112 have done well in these trials.

Hedysarum coronarium, or "Sulla", maintained its yield quite well for two seasons under grazing, in spite of not having been inoculated. It is well worth further trial both in short-term grazing mixtures and as a forage crop in pure stand, especially at altitudes over about 7,500 ft. on well-drained fertile land. Its seeding is rather erratic under these conditions, being confined to specific plants, while others do not flower.

Indigofera arrecta: this short-term perennial shrub was quite persistent and palatable, but is woody and unsuitable for use in grazing mixtures. Certain strains may have a value as a browse plant in permanent grassland.

Indigofera spicata Forsk (=*hendecaphylla*): Creeping indigo is indigenous in many of the higher rainfall areas of Kenya. It was persistent, but gave a poor yield compared with the best grazing legumes; furthermore, certain strains are known to be toxic. In view of these disadvantages, trials at Kitale have been discontinued.

Indigofera subulata is a perennial herb which occurs in some of the drier parts of the Colony, usually on the red volcanic loams. It has proved to be persistent under grazing, but is inferior to lucerne with which it competes under these conditions. It is thought to have good possibilities for use in some of the lower rainfall areas where lucerne will not thrive, however, where it could either be used in grazing mixtures or as a fodder crop in pure stand. It is a good seeder.

Lespedeza stipulacea is an annual which is known in U.S.A. as Korean Lespedeza. At Kitale the plots established well and made fair growth in the first season, but failed to regenerate adequately in the second year. Its rather low yield and poor persistence were no doubt partly due to lack of inoculation, but in spite of this it is probably not worth further trial here, as it appears distinctly inferior to some of the other annuals which were equally handicapped.

Lotononis bainesii, a perennial species from tropical Africa, appeared to be inferior to Kenya white clover. As the correct inoculant was unobtainable, however, the test was inconclusive. Given proper inoculation it is worth further trial as a grazing legume, although it seems unlikely that it will equal white clover where the rainfall is adequate. It forms a dense, low-spreading growth, and sets a plentiful amount of seed which would be easy to harvest as this is produced on long stems well above the foliage.

Lotus mearnsii: this low-growing perennial herb is of good quality but lacked vigour and persistence when grazed. It does not merit further trial at Kitale, but may be useful on old lake bed soils with a high pH value where it occurs naturally. It is a good seeder.

Lotus tigrensis, which is another indigenous perennial, is very slow to establish and gave a poor performance under grazing. Further trial would be unjustified.

Medicago denticulata, or Burr medic, is a well-known annual of Mediterranean origin which proved to be palatable, of good quality, and quite vigorous when correctly inoculated and adequately supplied with soil nutrients. It is slow to regenerate from seed, and less reliable than some other annuals in this respect. The burred seed pods would become a menace to wool sheep, though smooth seeded varieties are now available.

Medicago lupulina: an annual which is commonly known in Britain as Black Medic or Trefoil, made dense growth but was not equal to the better pasture legumes. It is not worth further trial in grass mixtures at Kitale, but may possibly be useful for sowing in pure stand for forage or catch cropping, especially at higher altitudes.

Medicago sativa: Lucerne is productive and persistent in grazing mixtures where properly inoculated and given favourable soil conditions, and it deserves extensive trial as a pasture legume. In some recent large-scale experiments at Kitale, it has remained productive for at least four years in grazing mixtures; and for still longer periods in other areas such as Ol Joro Orok, where the soil fertility is higher. Of the two varieties grown in these trials, "Hunter River" was distinctly superior to "Provence". Later experiments with lucerne have shown that "Saladina", "Hairy Peruvian" and "Booborowie" are also satisfactory in these conditions, while at altitudes over 8,000 ft. "Du Puits" has been giving good results.

Medicago truncatula, or Barrel medic made dense leafy growth, but gave a low yield compared with some other annuals, including Burr Medic. It is therefore not worth further trial at Kitale, where the conditions are good enough to support perennial clovers.

Melilotus alba, which is known in U.S.A. as Bokhara clover or sweet clover, has both annual and biennial varieties. An annual form, "Hubam clover", was used in these trials, and made quite vigorous growth in the establishment year. Although it is not very suitable for grazing mixtures, it has possibilities as a cover crop during ley establishment, or for annual green manure or forage production. None of the biennial forms was included, but it is thought that the sweet clovers should be tested more widely in the mixed farming areas of Kenya. Hubam clover produces good seed crops at Kitale, which can be harvested by combine harvester.

Melilotus officinalis, or Yellow sweet clover, is a moderately productive biennial plant which did quite well for two seasons under grazing. It appears to be very hardy and merits further trial for short-term ley mixtures, or possibly as a forage crop in pure stand. Its seeding qualities vary considerably with individual plants under local conditions.

Onobrychis viciifolia Scop. (=*O. sativa*), popularly known an Sainfoin, persisted for three seasons under grazing, but gave a low yield. This may have been due partly to lack of the correct inoculant, and partly to unfavourable soil conditions. Although it appeared to be inferior to some other legumes which suffered from the same handicaps, it probably merits further trial on a wider range of soils, and especially at higher altitudes.

Ornithopus sativa, Serradella, is a plant of Mediterranean origin which made poor growth compared with the best annuals, and is not suitable as a pasture legume at Kitale, although it appears likely to be used to a limited extent in certain localities at higher altitudes such as the Kinangop Plateau.

Pueraria phaseoloides, or Tropical Kudzu, was poor in comparison with the best twiners, being slow to establish and not persistent when grazed. It is not worth further trial at Kitale.

Rhynchosia ferruginea is an indigenous perennial twiner which proved to be poor in most respects.

Rhynchosia minima: this indigenous perennial twiner was vigorous but hardly palatable, and was of rather poor quality. It is not worth further trial.

Rhynchosia sennaarensis is another perennial twiner of local origin which will be discarded from further trials as it was unpalatable and is not persistent under grazing.

Stizolobium sp.: Velvet bean made vigorous growth but is unsuitable for grazing mixtures as it does not persist for more than a season. Certain forms may prove to be useful for undersowing in maize for ensilage, or to provide forage after harvest in the dry weather as they have made excellent growth under maize in some early trials.

Stylosanthes gracilis, which has been given the common name of Stylo, was quite productive and very drought-resistant and persistent when grazed, but was inclined to be woody and of poor quality. It is inferior to the best pasture legumes for the high rainfall mixed farming areas, but may be worth further trial for drilling into permanent grassland or for temporary leys in some of the drier districts of Kenya. It is a good seeder, but a very uneven ripener.

Stylosanthes fruticosa (Ret. 2) Mohlenbrock, is a perennial which occurs in semi-arid grassland. It is somewhat similar to *S. gracilis,* but appears to be less palatable and was generally inferior.

Stylosanthes sundaica, or Townsville lucerne, was much inferior to *S. gracilis* and is not worth further trial here, although it may possibly be of some value for sowing in drier areas.

Tephrosia holstii persisted well under grazing and was quite productive and palatable, but its form, being rather bushy and erect, is not suitable for general purpose leys. It makes dense growth and may be useful as a special forage or cover crop, more particularly for grazing in the dry weather.

Tephrosia linearis gave poor results in most respects and need not be considered for further trial.

Tephrosia subtriflora made poor growth and is not worth further trial at Kitale, but may do well if sown in semi-arid areas where it grows naturally.

Teramnus labialis, a local herb having a prostrate spreading habit of growth, gave poor yields and was not very persistent under grazing. It is distinctly inferior to the best pasture legumes and does not merit further trial.

Teramnus repens is similar to *T. labialis* in its general performance, and is not worth further trial.

Trifolium alexandrinum merits testing for annual hay or silage production, or as a cover crop during ley establishment, but as it does not regenerate freely from seed in a pasture mixture, it is unsuitable for general purpose grazing leys. It is extensively used in Egypt and some other Mediterranean countries where it is commonly known as Berseem.

Trifolium cheranganiense, a local species which has been named Cherangani clover, was persistent and palatable but comparatively unproductive, and was inferior to Kenya white clover. Further large-scale tests at Kitale would be unjustified at the moment, although trials at higher altitudes may be worth while.

Trifolium hybridum, known in Britain and on the Continent as Alsike, gave a comparatively low yield and did not persist for more than a season under grazing. Apparently it is not well suited to these conditions, but should be tried at higher altitudes in short-term ley mixtures, or as a forage crop in pure stand. It is a shy seeder.

Trifolium incarnatum, or Crimson clover, gave a low yield for one season and is inferior to the best annuals. It will probably not be tried again at Kitale on any scale.

Trifolium pratense, well known in Britain and other countries as broad red or late flowering red clover, did not do quite as well as the best short-term legumes, but warrants further trial for short-term leys at Kitale, and should undoubtedly also be tested on a variety of soils at higher altitudes.

Trifolium repens: Perennial white clover, of European origin, made satisfactory growth during the first season, but the varieties tried, New Zealand white and Ladino clover, were less hardy and persistent than Kenya white clover (*T. semipilosum var. glabrescens*). The trial was inconclusive, however, and it appears from more recent work that certain strains of *T. repens* have possibilities both under these conditions and at the higher altitudes. Amongst these, Louisiana white clover and Ladino clover appear to be particularly promising.

Trifolium rueppellianum, which has been named Rueppells clover, is one of the best annual legumes which were grown in these trials. From observations made elsewhere it appears to have possibilities for pasture mixtures on rather poorly drained land, or as an annual green manure or forage crop in pure stand, but it is unlikely to compete with the best perennial pasture legumes on well-drained soils where the latter will flourish. Its seeding was good and annual regeneration was satisfactory. The palatability appeared to be rather low when the plants were young, but increased with maturity. There are several distinct strains, the smaller of which may be more suitable for leys, and the larger fleshy-stemmed forms for annual cropping in pure stand.

Trifolium semipilosum var. glabrescens, or Kenya white clover, occurs naturally in many parts of the higher rainfall areas of this country from about 5,000–8,000 ft., especially east of the Rift Valley. It is clear from the work carried out during and since these trials that if associated with an effective strain of nodule bacteria, it is capable of making very vigorous growth wherever the soil and climatic conditions are favourable.

At present it is probably the best of the perennial clovers for our medium altitude, mixed farming areas, and is likely to be used extensively in general purpose ley mixtures. It proved to be the most successful perennial grazing legume in these trials.

Trifolium steudneri, another of the indigenous annuals, did not compare with *T. rueppellianum*. It occurs naturally on poorly drained land, however, and may be worth further trial on vlei soils at medium altitudes.

Trifolium subterraneum: only two varieties of Subterranean clover were tried, viz., "Yarloop" and "Mount Barker", but neither made good growth, and regeneration from seed was poor. It is clear from more recent work, however, that if properly inoculated and adequately supplied with soil nutrients, certain of the early maturing strains will grow and regenerate quite well in grazing mixtures at Kitale. Further work on these appears to be justified, more especially at the higher altitudes over about 8,000 ft., where the perennial clovers have so far not been very successful and where Subterranean clover is giving satisfactory results in some current experiments.

Trifolium tembense: although regenerating quite well from seed, this annual clover was distinctly inferior to *T. rueppellianum* when grazed in mixture with molasses grass at Kitale. However, it may do well at higher altitude in poorly drained "vlei" land, where it often occurs naturally.

Trigonella foenum-graecum, or Fenugreek, is an erect annual of Mediterranean origin which matured very rapidly, but which was clearly unsuitable for use in grazing mixtures. It would only warrant further trial if grown in pure stand for forage, seed, or green manure. The seed has a market value as human food and is used as an ingredient of curry.

Vigna gracilis proved to be persistent and quite productive under grazing but only during the rainy months as it withered rapidly after the onset of dry weather. It is of good quality but low palatability, and, although quite a good seeder, harvesting would be difficult due to its prostrate growth and the very uneven ripening of its small seed pods. It is found growing naturally in areas of high rainfall and high soil fertility.

Vigna oblongifolia is an annual or short-lived perennial twiner which was inferior to the best legumes of similar type in these trials.

Vigna schimperi: this twiner was quite productive during the first season, but did not persist under grazing. It is inferior to the best perennial twiners at Kitale, and further trials are not contemplated at present.

Vigna vexillata is another perennial twiner which was rather a poor yielder, but was hardy and moderately persistent when grazed. It will not be continued with at Kitale.

SUMMARY

An account is given of the grasses and legumes which have been grown in the preliminary grazing trials at Kitale.

The following species are either in use already or appear to warrant further attention, either at Kitale or under different conditions as indicated in the text.

GRASSES

Beckeropsis uniseta, Bothriochloa insculpta, Brachiaria ruziziensis, Cenchrus ciliaris, Chloris gayana, Cynodon dactylon, Cynodon plectostachyus, Dactylis glomerata, Enteropogon macrostachyus, Eragrostis caespitosa, Eragrostis curvula, Eragrostis superba, Festuca elatior, Hyparrhenia sp. nr. hirta, Lolium italicum, Melinis minutiflora, Panicum coloratum, Panicum coloratum var. makarikariensis, Panicum maximum, Panicum maximum var. trichoglume, Paspalum dilatatum, Paspalum malacophyllum, Paspalum scrobiculatum var. commersonii, Pennisetum polystachyum, Pennisetum purpureum, Phalaris tuberosa, Setaria longiseta, Setaria sphacelata, Setaria splendida.

FORAGE LEGUMES

many of which would be grown in mixture with grasses although not necessarily always: *Clitoria ternatea, Dolichos sp. nr. lablab, Glycine javanica, Hedysarum coronarium, Indigofera subulata, Lotononis bainesii, Medicago sativa, Melilotis officinalis, Onobrychis viciifolia, Ornithopus sativus, Stylosanthes gracilis, Tephrosia holstii, Trifolium cheranganiense, Trifolium hybridum, Trifolium pratense, Trifolium repens, Trifolium rueppellianum, Trifolium semipilosum var. glabrescens, Trifolium steudneri, Trifolium subterraneum, Trifolium tembense.*

ANNUAL LEGUMES

which would probably be grown for green manuring, hay, silage, special grazing, or seed: *Crotalaria incana, Crotalaria intermedia, Lablab niger, Medicago lupulina, Melilotis alba, Stizolobium (?) pruriens, Trifolium alexandrinum, Trigonella foenum-graecum.*

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REVIEWS

COMMON FRESHWATER FISHES OF EAST AFRICA, by Hugh Copley, published by H. F. and G. Witherby Ltd., London, 1958, 172 pp., 5 plates, 89 figs., price 25*s*.

The author has set out to create an interest in the freshwater fishes of East Africa, and has described, in simple terms and with clear line drawings, the form, habits, and distribution of 199 species. Although a check-list, an index of scientific names, and a bibliography are included for those who treat fish as something scientific, the book is written primarily for anyone who catches "a fish" and who wants to know more about it. Kiswahili and tribal names are given for most species, with an Index of Common and Native Names, in order that identification by a passer-by may be put to good use.

Even trout fishermen will find something of interest, since the author says of *Alestes affinis,* "They rise and take surface insects and can be caught on a wet fly, putting up, pound for pound, a better fight than any trout". Unfortunately the fingers, rather than the arms, would be used to describe "the one that got away", for the average length of *Alestes affinis* is six inches. The Nile perch needs more elbow room, as it may scale 265 lb., and between these comes the Tiger fish, which gives excellent sport on the spinning rod and may be as large as 35 lb. although it averages 5 to 8 lb.

This book achieves its objective and can be recommended to anyone with even a mild curiosity about the freshwater fishes of East Africa.

D.W.D.

PIG CARCASS EVALUATION, by G. Harrington. Technical Communication No. 12 of the Commonwealth Bureau of Animal Breeding and Genetics. Obtainable from the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 107 pp., 1958, price 15*s*.

In the words of the author "The purpose of this review is to describe and compare the many different techniques which have been considered in the assessment of quality in pig carcasses, in circumstances ranging from detailed scientific experiments to slaughterhouse grading". The fact that 373 publications are referred to in the text is an indication of the large amount of work which has been done on this subject, but, as yet, there is no really satisfactory method of grading pigs, particularly for the production of bacon and ham.

The main sections of the book deal with the estimation of carcass composition after slaughter, the evaluation of the live pig in terms of carcass composition, the determination of the qualities of fat and lean, the evaluation of other characteristics affecting quality, and carcass evaluation in the field. Throughout the review the author has kept in mind the fact that the consumer has the last word, and the appearance, keeping qualities, and taste of the final product is the ultimate criterion. The book is of great value in that it is a carefully considered summary of the present position, and it should provide a stimulus, both in the laboratory and in the factory, for more work on this important subject.

D.W.D.

ALUMINIUM PHOSPHIDE FOR BULK GRAIN FUMIGATION IN UGANDA

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Although aluminium phosphide has been used in Germany for over 20 years as a grain fumigant, it is only recently, with the patenting of a new formula, that the method has received renewed attention by outside countries. The new formulation consists of aluminium phosphide combined with ammonium carbamate, which latter readily decomposes into carbon dioxide and ammonia, enabling a much finer grinding of the aluminium phosphide to be carried out in the presence of the carbon dioxide evolved. A result of this is that the tablets decompose more readily and completely and at the end of the fumigation no special steps need be taken to remove any residues. The normal dosage is from 10–15 tablets a ton depending on the conditions under which the grain is stored. Each tablet weighs about 3 grams.

The method consists of introducing tablets of the phosphide into the grain. The moisture in the grain causes evolution of phosphine, the tablets breaking up into harmless reaction by-products. The amount of unchanged phosphide is negligible. The gas is toxic to all stages of insects, but some species and some stages of particular species are more resistant than others. In large silo-type bins it is recommended that the tablets be thrown into the grain stream as it enters the bin, but with large horizontal bulks a special injector can be obtained which can also be used for small 20-ton silos.

There is very little evolution of phosphine for the first hour or so, and as a rule no respirators need be worn if the job is carried out efficiently. The tablets are supplied in sealed containers of three sizes containing 900, 360 and 90 tablets respectively.

EXPERIMENTAL METHOD

Since to the best of my knowledge the method had never before been tried in East Africa I was very pleased to have the opportunity to carry out observations on a fumigation at a plant at Jinja. This plant has 32 welded steel bins, each bin having a capacity of 4,000 bags. The bins are fitted at the bottom with a tight gasket on the delivery hole, to which a chute can be attached which carries the grain to a conveyor. The bin base is coned to allow grain to flow out easily and grain can be turned from one bin to another with the minimum of inconvenience. The tops of bins are fitted with conical metal hoods like Chinese hats which provide free access to the air. In the trial described the bin held 387 bags of infested maize.

As the maize was turned from one bin to another the tablets were added to the grain stream as it entered the bin to be used in the fumigation. A stop-watch was used to time the intervals calculated at one tablet per 20 seconds with a grain flow of three bags per minute. In actual fact a slightly heavier dosage was added in the first instance, but since it appeared from the figures that the actual grain flow was nearer four bags per minute this was largely offset. It took just over 1½ hours to complete transfer and dosage. The conical "Chinese hat" at the top of the bin was stuffed tightly with gunny bags to cut down the loss of phosphine to the air. No inconvenience was experienced by the operators adding the tablets by blow-back as the bin was filled. Rubber gloves were worn while handling the tablets.

Samples were taken at 10-minute intervals at the discharge bin chute. These were placed in tight-weave sample bags, labelled and brought to the laboratory for examination on the following day. The samples were sieved and 500-gram lots of the maize from each sample were incubated at 28–29° C. and R.H. 80 per cent +. A note of the number of insects alive and dead in the whole samples was taken. The moisture content of samples was taken on arrival in the laboratory using a fine grind (1 mm. sieve) in an electrically operated laboratory mill and a Marconi moisture meter. A count of insect-damaged maize grains was taken. (1,000 grains were counted from each sample and examined.)

PREFUMIGATION SAMPLES

The average moisture content of the ten samples taken varied little from 12.5 per cent. Five samples in the region of 500 grams each (average 531 grams) and five in the region of 1,300 grams (average 1,347 grams) were taken. Sieving of these samples gave the average numbers of adult insects shown in Table I.

TABLE I

Calandra	*T. castaneum*	*Cryptolestes*	*T. mauritanicus*	Others	Average % bored
500 *gram samples* 19·4D, 1A	1·2D, 8A	·2D, 8A	·6D, ·4A	·6D, 0A	34·4
1,300 *gram samples* 32·8D,5,4A	3D, 4·6A	–D, 3A	·4D, ·2A	4D, 1·2A	35·3

A=Alive. D=Dead.

These figures show that the bin was fairly heavily infested with most of the more important grain insects and had undergone a considerable attack. *Cryptolestes* species identified were *C. minitus, C. ugandae, C. ferrugineus,* and one specimen of *C. pusilloides. C. minitus* was by far the commonest. Other insects found (and included in the "others" column) included *Rhizophertha dominica, Oryzaephilus surinamensis, Carpophilus dimidiatus, Araecerus fasiculatus,* and *Acanthoscelides obtectus.* The latter were present due to bean mixture.

After sieving 500-gram lots of each sample were incubated. One month later the samples were sieved and a count of insects alive and dead taken (*See* Table II.)

TABLE II

C. oryzae	*T. castaneum*	*Cryptolestes*	*T. mauritanicus*	Others	Weight of frass
7·9 D 34·5 A	3·2 D 12·7 A	2·4 D 9·8 A	·2 D ·2 A	1·1 D ·2 A	1·43 g

These figures prove conclusively that the maize was heavily infested with all stages of insects. Larvae of *T. castaneum* were common but for brevity's sake are not included in the figures. One specimen of *Lophocateres pusillus* was recorded.

POST-FUMIGATION RESULTS

The bin was under gas for some four weeks (14th February to 19th March, 1958). On removing the sacks from the metal cowl on the top of the bin no smell of gas was detectable and the same observation was made when the hatch at the top was opened. The grain was then run off at the bottom of the bin and elevated to another bin. While this was proceeding, samples were taken at 5–10-minute intervals. Some slight smell of phosphine was detectable at the sampling point and a stronger smell noticeable in the machinery house containing the elevators, etc. This was minimized by opening all windows and running the fans. Nineteen samples were taken in all. Of these only two had any live insects—one live *Tribolium castaneum* was found in one sample and one live *C. oryzae* in another. The latter was in the very last sample taken which was very dirty and dusty. It is just possible that the *Tribolium* survival flew into the sample as it was being taken at the bin bottom since a few were seen in flight. The average sample weight was 1,407 grams. (*See* Table III.)

TABLE III

C. oryzae	*T. castaneum*	*Cryptolestes*	*T. mauritanicus*	Others	% damaged
128·4 D 1 adult survival	11·9 D 1 adult survival	5·5 D	·9 D 2 (1) D	2 D	34·4

(1)=larva.

500-gram sub-samples from all samples taken at the time of opening were then incubated as before for one month and at the end of this period sieved. Four were completely free of insects and a further nine had four insects or less, all dead, comprising *C. oryzae* 6D, *T. castaneum* 3D, *Cryptolestes* 1D, *T. mauritanicus* 4(1)D, others 1D. Of the remaining six samples one only (sample 19) was considered to have a potentially dangerous population (*See* Table IV.)

At the end of six weeks' incubation the situation had not radically altered. Two samples gave one live *Tribolium* each. Sample 19 gave ten adult *Tribolium*, four larvae and two pupae. Sample 20 gave one live *E. cautella* adult, one *C. oryzae* alive, one dead and one *Ephestia* pupa alive. In addition three dead *Ephestia* larvae were sieved out of another sample.

TABLE IV

Sample:	*C. oryzae*	*T. castaneum*	*T. mauritanicus*	*Ephestia cautella*	Others
4 ..	1 (a) A	1 (a) A	—	1 (1) A	—
7 ..	—	1 (a) A	2 (1) D	—	—
13 ..	1D (a)	1 (a) A	—	—	—
19 ..	1D	1 (a) A 22 (1) A	— 1 (1) D	— —	— —
20 ..	1D	—	—	5 (1) A	—

(a)=Adult. (1)=Larva.

DISCUSSION

The figures provided show that the initial infestation in the maize used in this experiment was considerable and that a reasonable range of stored grain insects were present. The initial kill obtained using a dosage of 10.2 tablets per ton (the minimum recommended by the manufacturers is 10) was very satisfactory, only two live adult insects being found on sieving post-fumigation samples. One of these may possibly have flown into the sample as it was being taken since a few flying adults of *Tribolium* were observed at the time of sampling.

The fumigation was carried out in most favourable conditions since all the bins in Jinja are reasonably gas-tight (except at the "Chinese hat" which in this case was stuffed with gunny bags), but it should be remembered that the amount of free air space was quite considerable. No information can be given about gas distribution in the bin since apparatus for sampling and analysis is not available at Kawanda. Some leakage of gas could be expected through the gunny bags at the tops of bins. No satisfactory method has yet been discovered for actually finding out where the tablets lodge once introduced into the grain stream. It would appear, however, that they would tend to run down the cone towards the sides.

The post-fumigation incubation samples show that at this dosage some survivals of both *T. castaneum* and *E. cautella* can be expected. Work in the United Kingdom and Germany has indicated that the pre-adult stages of *C. oryzae* are rather resistant to the fumigant, but at Jinja *C. oryzae* appears to have been very successfully controlled.

As the bin was turned a slight smell was detectable at the bin outlet but it was not uncomfortable and no respirators were worn. No ill-effects were noticed though there was a tendency for one's nose to run. The smell was stronger in the machinery house, but again did not interfere with normal working when windows were open and fans were run.

Taken as a whole, the fumigation was very successful, though Sample 19 did appear to have sufficient insects to form a focus of reinfestation. This sample was taken right at the end when the bin for all practical purposes had been emptied, and was obtained by banging the bin sides with a chunk of wood. The dirt and dust present in the sample may have prevented satisfactory penetration of the fumigant. A staff member who has had considerable experience of up to a dozen different treatments at the plant ranging from the use of pyrethrin dusts to chloropicrin fumigation considered this treatment to be the most effective he had seen.

It is hoped to carry out a further test in the near future using a full bin, and the method will also be tried out in Uganda on small bins of 20 tons and 30 cwts. since it is very likely to find application at some of the larger institutions in Uganda.

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THE EFFECTS OF MAIZE IN PIG RATIONS

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Maize has the reputation of being unsuitable for bacon pig rations except in relatively small proportions, mainly because it is said to produce soft carcass fats. As the published evidence for this opinion is not conclusive, we considered that an explanation of the action of maize might be obtained by substituting it in increasing proportions for the barley and pollards of a standard fattening ration. This standard ration consisted of 67 per cent barley meal, 25 per cent pollards, 6 per cent carcass meal and 2 per cent minerals, and by substituting maize for first the barley meal and then the pollards six rations were made up containing 15, 30, 45, 60, 75 and 90 per cent maize, the carcass meal being adjusted to keep the total crude protein fairly constant, between 14 and 16 per cent. Eighteen large white pigs (13 females and five males), from several litters, were divided into six groups of three each, chosen at random, and were fed *ad lib.* from 100 lb. live weight to slaughter weight (200 lb.) on these rations, given as a wet mash. They had access to green food every day. Feed consumption and liveweight increase were measured, and samples of fat from the shoulder, mid-back and loin were taken 24 hours after slaughter for analysis by the Hanus method for iodine value.

FAT HARDNESS

The earliest record we could find concerning the effect of maize in pig rations was by Friis (1895) who reported that in experiments with bacon pigs those fed barley throughout produced pork which was almost twice as hard as that of pigs fed on maize. Carlyle and McConnell (1902) found that in pigs fed corn "the fat was soft and flabby, almost blubbery to the touch, and the muscle was pale in colour and appeared to lack tone". Henriques and Hansen (1901) showed that the feeding of maize to pigs produced a more unsaturated, and therefore softer fat than the feeding of barley, and they gave iodine values of the outer back fat of 58.5 per cent with barley and 71.5 per cent with maize. Callow (1931) reported that diets containing 23–31 per cent maize produced soft bacon fat, while rations containing 43–62 per cent maize produced relatively hard fat. Callow and Kitchin (1931) also found that the rate at which a pig grows appears to affect the iodine number of the fat. Fast-growing pigs tend to have hard fat with a low iodine number, and slowly growing pigs to have softer fat with a high iodine number.

Romyn (1936) studied the cause of soft fat in a bacon factory in Southern Rhodesia, where iodine values of 66–76 per cent had been obtained. He came to the conclusion that the rations in themslves were not the cause of the trouble, but that the pigs with soft fat had not been properly finished. He states "It is of interest to note that this outcrop of soft pigs has coincided with a shortage of maize for feeding". The usual ration was maize plus separated milk, but during a shortage of maize the rations were sometimes made up with purchased wheat by-products. These bought feeds were fed lightly to economize expenditure, and the pigs were given a good deal of roughage and were marketed at light weight in order to keep down feed costs. Baskett (1939) set out to find the maximum quantity of maizemeal which can be used without detrimental effect on the fat of bacon pigs, using rations ranging from 20 to 60 per cent maize, and found that pigs on the higher levels of maize did not grade so well as those on the lower levels. Murray (1942) concluded that both slow growth and lack of finish are two very important causes of soft fat. He found that meatmeal, bloodmeal, and bonemeal, when fed with maize to early maturing pigs, produce firm fat, and that these supplements can replace skim-milk.

Vestal and Shrewsbury (1944) found that the fat content of a maize feed was important: hominy containing 5 per cent fat had a tendency to produce soft carcasses and bacon, while the same type of maize feed with 7 or 8 per cent fat had a very definite softening effect on the body fat. Maize containing 4 per cent fat produced firm carcasses and hams, but some soft bacon. On the other hand Terrill *et al.* (1951) fed two types of maize, one containing 4.7 and the other 6.4 per cent fat, plus a protein supplement containing meat and bone, soya bean oil, and alfalfa meal, and found no significant differences between the two groups in rate of gain, carcass grade, or fat hardness. Shorland *et al.* (1944) tested the effect of skim-milk as a supplement to maize, and reported that restriction of the amount of skim-milk fed resulted in a significant softening of the carcasses, but the iodine values which they give are those of hard fats from the bacon curer's point of view, only three iodine values out of 96 being above 65. Gorb *et al.* (1955) concluded that a diet containing 75 per cent maize has no detrimental effect on fat production in pigs. They found that maize tended to increase the weight gain, and suggested that maize can profitably be substituted for other constituents of the diet.

In our feeding trial with rations containing proportions of maize ranging from 15 to 90 per cent, samples of fat from the shoulder, mid-back, and loin were taken 24 hours after slaughter, rendered at 80° C., and analysed by the Hanus method for iodine value as described by Snell and Biffen (1944). In considering the results the effect of sex was removed, to some extent at least, by adding 1.7 to the iodine values of fats from male pigs, a factor suggested by Lush *et al.* (1936) to make them comparable with fats from females. Table I gives the group averages of these corrected iodine values, and it shows a tendency for the fat to become softer (i.e. with a higher iodine value) as the percentage of maize in the ration increases.

Table I.—Corrected Iodine Values of Carcass Fats

(*Group averages*)

% maize in ration	Shoulder I.V.	Mid-back I.V.	Loin I.V.
15	59·9	61·2	61·4
30	62·8	62·5	61·9
45	62·3	63·3	62·4
60	62·7	66·6	65·3
75	63·8	65·6	64·2
90	63·8	65·0	64·5

Note.—Hankins and Ellis (1926) give the following relationships between iodine value and hardness of fat: 63·0 hard; 68·0 medium hard; 71·0 medium soft; 77·5 soft; 88·0 oily.

Since there was a rather wide variation in the iodine values within groups, the corrected iodine values for the individual pigs were analysed statistically, to find if there was a definite trend in the effect of maize on fat hardness. All three sets of figures, for shoulder, mid-back, and loin, gave separate regression equations which were significant at the 20/1 level, which is probably as good as could be expected from the relatively small number of data involved. In each case the trend was towards softer fat with increasing percentage of maize in the ration, but as all the fats were sufficiently hard for bacon-curing there is no evidence to support the opinion that maize tends to produce soft, oily fats in bacon carcasses. This is supported by the factory grading of the fats. Fifteen of the pigs had their fat graded "Very Firm", while the fats of the remaining three, on 15, 45, and 60 per cent maize, were classed as "Firm".

Feed Conversion and Carcass Grade

The feed conversion ratios (lb. feed required to produce 1 lb. liveweight gain) of the 18 pigs in the trial are given in Table II.

Table II.—Feed Conversion Ratios

% maize and sex	Feed Con. Ratio	% maize and sex	Feed Con. Ratio
15 F 15 F 15 M	3·9 3·4 3·8	60 F 60 F 60 F	4·6 3·5 3·5
mean	3·7	mean	3·9
30 F 30 F 30 M	4·1 3·8 3·7	75 F 75 F 75 F	4·3 4·0 3·1
mean	3·9	mean	3·8
45 F 45 F 45 M	5·0 3·7 3·8	90 M 90 M 90 F	3·9 3·0 4·5
mean	4·2	mean	3·8

Although the group means might suggest that the poorest feed conversion was obtained with 45 per cent maize in the ration, the variation within the groups is too great to enable any conclusions to be drawn. The effect of sex did not appear to be distinctive.

It was apparent during the trial that the pigs on the 75 and 90 per cent maize rations were growing more slowly than those on the low-maize rations, and it would appear from the feed conversion ratios that the former pigs were eating less per day than the latter. This suggests that palatability may be a factor in high-maize rations: the ration highest in maize, for example, consisted of 90 per cent maize, 8 per cent carcass meal, and 2 per cent minerals, and it is possible that this may not have been sufficiently palatable, but there were no signs of feed refusal or hesitation when the pigs were fed.

The effect of maize on carcass grade was a trend towards lower grading as the percentage of maize in the ration increased. All the 15 per cent maize pigs were Grade A, the groups on 30, 45 and 60 per cent maize each produced two Grade A pigs and one Grade B, and the 75 and 90 per cent maize groups each produced one Grade A and two Grade B pigs.

LIVEWEIGHT GAIN

The average daily liveweight increase of each pig in the trial is shown in Table III, and the group means along with the crude protein contents of the rations, are given graphically in Fig. I.

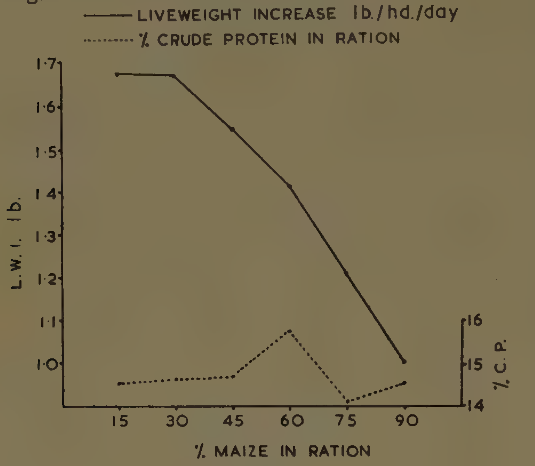

FIG. 1

TABLE III.—DAILY LIVEWEIGHT INCREASE (100–200 lb.)

% maize and sex	L.W.I./day lb.	% maize and sex	L.W.I./day lb.
15 F 15 F 15 M	1·40 1·82 1·81	60 F 60 F 60 F	1·37 1·32 1·54
mean	1·68	mean	1·41
30 F 30 F 30 M	1·45 1·59 1·96	75 F 75 F 75 F	1·22 1·26 1·15
mean	1·67	mean	1·21
45 F 45 F 45 M	1·19 1·68 1·74	90 M 90 M 90 F	0·87 0·88 1·28
mean	1·54	mean	1·01

In spite of variation within the groups, the means show a remarkably steady decrease in liveweight gain with increasing proportions of maize above 30 per cent. Even allowing for some coincidence in the regularity of the decrease there is an obvious trend which cannot be related to the percentage of crude protein in the ration.

No previous records could be found of experiments on the effects of maize on the growth of pigs during the fattening period, but several trials have been carried out in which high-maize rations were fed to weanlings or young pigs. Fuller (1904) reported that a group of pigs fed exclusively on maize became dwarfed animals. While they gained some flesh they did not develop in bone, and towards the end of the trial they were indifferent about eating. Powell (1931) fed 25 young pigs of about 50 lb. liveweight on maize and tankage offered in separate self-feeders. The animals adjusted their feed intake to an average of 84 per cent maize and 16 per cent tankage, this mixture having a crude protein content of about 18 per cent. Their appetites were good throughout the test, and they averaged a daily liveweight gain of 1.26 lb. Yet some of them had large pockets of liquid on the joints, which could not be cured by turning them out to Sudan grass, or by feeding cod liver oil or a complex mineral mixture, and it was concluded that there was a direct relationship between tankage and the trouble. Birch *et al.* (1937) fed young weanling pigs on a ration containing 83 per cent maize plus pea meal, casein, cod liver oil, and minerals, the crude protein content of the whole ration being 10.8. The animals became ill and died unless the ration was changed: increasing the casein to give a ration with 12.6 per cent crude protein did not prevent the trouble, but by adding dried yeast and reducing the casein to give 11.1 per cent protein in the ration the pigs were reared satisfactorily, with an average daily liveweight gain of 1.25 lb. Contescu *et al.* (1936) obtained daily liveweight gains averaging 0.9 lb. with young pigs fed solely on maize over a period of 153 days, the feed conversion ratio being 5.4, but in a repetition of this trial they had much slower growth with occasional loss of weight: softening of the bones of the forelegs also occurred. In this second trial the feed conversion ratio was 6.3.

From this evidence, and from the results of the trial which we carried out, it can be concluded that maize is deficient in one or more of the essential food factors. Some protein supplements seem to alleviate this deficiency to some extent, but it is clear that the total crude protein content of a high-maize ration is not a good indication of its nutritive value for pigs.

The markedly slower growth on high-maize rations would account for the tendency for the fat to become softer with increasing maize in the ration, according to the findings of Callow and Kitchin (1931) which are mentioned above in discussing fat hardness. Thus it may not be the relatively high oil content of maize compared with barley which causes the softening of the carcass fat, as suggested by Woodman (1957); a nutritional deficiency in maize, resulting in slower growth, may be a better explanation of the effect.

VITAMIN DEFICIENCY IN MAIZE

The effect of maize in retarding growth can be explained, in part at least, by published evidence that maize is deficient in one of the B group of vitamins. For example, the results obtained by Birch *et al.* (1937), which are summarized above, indicated that one or more of the B_2 vitamins was a factor in the nutritive value of maize, since dried yeast had a very beneficial effect when added to the high-maize ration which they used. Nicotinic acid, sometimes called niacin, is believed to be the particular B_2 vitamin involved in this nutritional deficiency, but the problem is complicated by the fact that tryptophan, one of the amino-acids which forms part of most, if not all, vegetable and animal proteins, can give rise to nicotinic acid in the digestive system of the non-ruminant. Thus tryptophan has two functions in food, one to provide one of the constituents of muscle protein, and the other to give rise to nicotinic acid during the digestive processes. Nicotinic acid is present in food in very small quantities, and if this supply of the vitamin is inadequate further requirements are synthesized from the tryptophan of the protein in the food. But Krehl *et al.* (1946) suggested that, if the essential amino-acids, of which there are ten, are out of balance in the food, there may be a drain on the tryptophan, and the requirement of tryptophan in the diet may thus be increased. They concluded that zein, the predominant protein in maize, is unbalanced in this way, and that synthesis of nicotinic acid in the body may be reduced in high-maize diets. Leucke *et al.* (1947) found that young pigs grew well on a diet containing 80–87 per cent maize, with supplementary vitamins including nicotinic acid, the total crude protein of the ration being 19.2 per cent. Their daily weight gain averaged 1.4 lb., and their feed conversion ratio was 2.6. On the same ration, but without added nicotinic acid, three out of five pigs developed scouring within four weeks and their feed conversion ratio rose to 3.0. At autopsy, lesions characteristic of nicotinic acid deficiency were found in the large intestine. When the protein content of the ration was decreased to 14 per cent it was found that 30 mg. nicotinic acid, the additive which had been successful in the first trial, was not sufficient to correct the deficiency, and the daily liveweight gain was only 0.76 lb., compared with 0.62 lb. for pigs on the same ration without nicotinic acid. The latter pigs showed symptoms of nicotinic acid deficiency. Another group of pigs on this high-maize ration with 14 per cent protein were given a daily supplement of 200 mg. tryptophan but no nicotinic acid. Their daily gain averaged 1.0 lb. and their feed conversion ratio 2.29, but there were slight symptoms resembling those of nicotinic acid deficiency, so the extra tryptophan may not have been quite sufficient to correct the deficiency of nicotinic acid.

This deficiency of actual or potential nicotinic acid in maize is emphasized further by the work of Braude *et al.* (1955) and Kodicek *et al.* (1956). They showed that almost all the nicotinic acid in maize is in a "bound" form which cannot be utilized by pigs, but which can be made available by alkaline hydrolysis of the maize. Weanling pigs on a nicotinic acid-deficient diet containing 79 per cent maize gained no weight over a period of nine weeks, whereas a group on the same ration with supplementary nicotinic acid gained an average of 5.0 lb. per week each. The maize of the same ration was hydrolysed with weak sodium hydroxide to liberate the nicotinic acid and fed to a third group without supplementary nicotinic acid: their average weekly liveweight gain was 3.2 lb.

AMINO-ACIDS IN MAIZE

The suggestion by Krehl *et al.* (1946) that the amino-acid composition of maize is out of balance leads to the possibility that the requirement of tryptophan may be higher with maize than with other cereals. This suggests that in selecting protein supplements for use in high-maize rations considerable attention should be paid to their tryptophan contents. The optimum amount of supplementary nicotinic acid may not be critical, in that a moderate excess will probably do no harm, but it may be important to find the optimum percentage of tryptophan in the ration, since an excess of this amino-acid might throw the other amino-acids out of balance and thus reduce the efficiency of protein utilization.

Other amino-acids will also have to be taken taken into consideration, and in this connexion a recent paper by Evans (1958) is of particular interest. Evans studied the requirements of the pig for lysine and for methionine plus cystine, and came to the conclusion that in the growth period between 90 and 150 lb. liveweight the rations should contain about 0.37 per cent lysine and 0.36 per cent methionine plus cystine. Using data by Harvey (1956) and by Fowden and Wolfe (1957) we calculated the contents of these amino-acids in the rations used in our trial: the lysine contents ranged from 0.43 to 0.51 per cent, and those of methionine plus cystine from 0.50 to 0.58 per cent, so it seems that these amino-acids were adequately supplied in the rations used.

Evans also gives the tryptophan content of a ration which was found to give maximum growth from 90 lb. to slaughter weight as 0.13 per cent. The tryptophan contents of the rations used in our trial ranged from 0.13 to 0.10 per cent, the highest figure being for the 60 per cent maize ration and the lowest for that containing 90 per cent maize. Thus the regular decrease in liveweight gain with increasing maize could not be accounted for by the total tryptophan contents of the rations, but the proportion of the total tryptophan which was derived from maize rose steadily from 11 per cent in the 15 per cent maize ration to 87 per cent in the 90 per cent maize ration.

SUMMARY

In a feeding trial 18 Large White pigs were fed from 100 lb. to slaughter weight (200 lb.) on rations containing 15, 30, 45, 60, 75, and 90 per cent maize, the total crude protein content of the rations being kept fairly constant. While there was a tendency for the carcass fat to become softer, with a higher iodine value, as the percentage of maize in the ration increased, all the fats were suitable for bacon curing. The factory grading of the carcasses tended to be lower the higher the maize content of the ration, but none was below second grade.

A striking relationship was found between the rate of liveweight gain and the percentage of maize in the ration. The group averages for the 15 and 30 per cent maize rations were both 1.7 lb./hd./day, and thereafter there was a steady drop to 1.0 lb./hd./day for the 90 per cent maize ration. The effect of maize in reducing growth rate seems to account for the tendency for the fat to come softer as the percentage of maize in the ration increases.

This drop in growth rate also indicates a nutritional deficiency in maize, possibly nicotinic acid, and it is suggested that supplementary nicotinic acid might be of value in high-maize rations.

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INDIGENOUS RIVER FISHING METHODS IN KENYA

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The fishing methods described here are those which have been employed on Kenya rivers for hundreds, perhaps thousands, of years. African rural settlement has always been controlled by the proximity of water, and daily visits to streams, rivers and lakes must from early times have revealed the vast potential source of food abundant in the freshwaters of Kenya.

Many of the fishing devices used, such as the wicker basket trap, have a wide distribution throughout the African continent. Indeed, the principle underlying almost all trapping devices is found in many widely separated regions. Thus the fishermen of Lake George and the Jaluo of Nyanza Province, Kenya, employ identical baskets for trapping in shallow swamps (the *ihafwa* shown in Fig. 1B). Again, the highly developed barrier traps (*kek*) of the Jaluo appear in identical form but on a larger scale on the Congo. Although an ancient prototype is probable, biological and mechanical necessities so govern design that the possibility of independent discovery and elaboration cannot be dismissed. Oral tradition, which may reach back seven to ten generations, has, however, thrown little light on the evolution of fishing methods, the present designs being apparently much older than this. Archaeological evidence in Kenya has also been disappointing, being scanty and limited to fish remains in association with culinary artefacts or occasionally bone hooks. Basket traps and barriers do not survive long in an area of ever-changing river courses. In Egypt, however, an accurate pictorial record has survived which shows that line fishing, spearing and netting were already practised in the 5th Dynasty (2,500 B.C.) and that pond culture of *Tilapia* can be dated from the same period (Chimitz, 1958). There is, however, no indication in the bas reliefs quoted of woven basket traps although one might expect their invention to have preceded that of nets.

In the past the large and important cichlid fisheries of Lake Victoria have overshadowed what little was known of river fishing activities. But recently, two surveys have been undertaken by the Fishery Division (Research) of the Ministry of Forest Development, Game and Fisheries (on the lower Athi (or Sabaki) and on the rivers of Nyanza Province), and these have shown that an abundant source of animal protein has been steadily harvested from the rivers—so efficiently in some cases that its very existence is now threatened by overexploitation. For, until the beginning of this century, before population densities began to rise and exotic fishing gear was introduced, the exploitation of river fishes in Kenya probably did not exceed the natural rate of replenishment, a situation which may be characteristic of primitive societies before the establishment of monetary gain. Under these circumstances, self-imposed conservation measures, such as the taboos on the slaughter of cattle, were unnecessary and the need or desire for artificial culture or propagation of stocks did not arise. Hence unreserved exploitation has become an accepted attitude, and with the establishment of the cash nexus even a virtue—to the detriment of fish resources.

As elsewhere, the efficiency of river fishing devices depends largely on a knowledge of the biology of the fishes, and in this respect the Kenya fishermen are highly skilled. They have a good knowledge of the breeding and feeding habits of river fishes and pay a surprising amount of attention to detail in identifying and naming their catches. Thus several growth stages of the large catfish (*Clarias mossambicus*) are recognized and named according to their habits and habitat, while all are known to belong to the same species, despite the presence of two other taxonomically similar species. Again, the second and most important species of *Tilapia* in Lake Victoria was described by Michael Graham (1928) only after it had been distinguished by African fishermen. But the greatest influence on river fishing devices has undoubtedly been the knowledge that certain species are strongly migratory, ascending rivers and streams during the breeding season. The largest and most productive methods are those which have been designed to catch such migrating fishes.

The rivers of Nyanza Province are all affluent to Lake Victoria and the majority of river fishes are anadromous, spending most of the year in the main lake, but running up the rivers during the rainy seasons to breed.

Huge shoals collect outside the mouths of rivers prior to the rains, where they are caught in gillnets. At each major flood the adults run up the rivers, reaching, occasionally, 50 or 60 miles inland. Elsewhere in Kenya these runs are confined to the rivers themselves, but the upward surge of fishes in the rainy months follows a similar pattern. African knowledge of these runs is extensive and often a little mysterious. The runs of *Clarias mossambicus* up small streams, for example, are of very short duration and usually occur at night. Yet, the runs are seldom missed by African fishermen though they may take place on only two or three days in the year.

A primary division can be made between those devices used for catching migrating fishes and those which are adapted for static populations in swamps, floodwater pools or quiet reaches of rivers. The former are the more efficient, relying on the active movement of migrants into the traps or their concentration into dense shoals. Such devices are therefore not usually baited and tend to be static. For permanent populations moving in a random manner either a lure is necessary or some amount of energy must be expended in order to sweep, with basket, net or barrier, an area large enough to compensate the low density of fish.

The rivers of Kenya fall into three natural groups. Those to the west of the Rift Valley empty into Lake Victoria, those to the east flow eastwards to the Indian Ocean, while the rivers and streams within the Rift itself have a north-south trend but are, for the most part, intermittent. Large rivers, such as the westward flowing Nzoia, Kuja and Yala rivers of Nyanza Province, or the Athi and Tana rivers to the east of the Rift, are permanent throughout the year, but smaller streams are often ephemeral, drying out completely during the dry season. But even the larger rivers dwindle during the dry months and this respite affords the fishermen time to repair damage to static fishing devices.

FISHING METHODS

Line Fishing

Line fishing, the most universal and perhaps the most primitive of all fishing methods, is practised extensively throughout Kenya. Catching one fish at a time, the single hook and line is the most time-consuming of all methods, the more so since it requires the search for or capture of bait and because it usually relies on static, widely dispersed populations. It is not considered a serious source of food unless the species caught attain at least a pound in weight, and it is therefore usually carried out by boys of school age. Twenty years ago, home-made barbless hooks were still used on Lake Victoria (Dobbs, 1928), but nowadays hooks can be purchased at any of the small shops in country districts. Originally, lines must have been made from some type of plaited vegetable fibre, but twine or fishing line can now be bought cheaply, and monofilament nylon is becoming popular.

In streams, swamps and floodwater pools, a short, 3-4-ft. rod is employed, the hooks being baited with a paste made from maize millings, or with worms, frogs, insects or small fishes. The line is also short and, where the water is clear and the fishes can be watched, no float is used. Small species only are caught in this way and a day's catch rarely exceeds half a pound.

On major rivers in Nyanza, however, a longer rod is used for catching the large migrant *fwani* (*Barbus altianalis radcliffi*). The *fwani* rod is between eight and ten feet long and is made of bamboo, the last two feet being extremely thin and flexible and attached separately. There is no reel and the line is tied to the end of the rod. Hooks are baited with maize paste, worms, flying ants and, apparently, with wild figs. In one instance a crude fly of chicken feathers was seen, baited also with ants for good measure, and the combination was deemed "irresistible". *Fwani* rods are used to catch the upgoing fishes, and turbulent areas below falls and rapids are particularly exploited since here the *fwani* tend to congregate before attempting the ascent. Lines are cast into midstream and in the dry season the fishermen wade out into the river, their bait and catch tied to their waists.

The well-known long or night line is also used in Kenya wherever there are large bodies of water. Occasionally they are used in the rivers too. The line, sometimes 200 yards long, is supported by floats of cork or ambatch wood (*Herminiera* sp.) and is anchored with poles or stones. Up to 600 hooks are attached to snoods tied at intervals along the line. Long lines require large scavengers or predators which will play themselves to exhaustion against the line, and thus the main genera caught in Kenya are *Clarias, Protopterus* and *Bagrus* in the lakes and swamps, and *fawni* in the rivers. The bait used varies from small

Haplochromis spp. or silvery strips cut from the flanks of larger species, to molluscs for *Protopterus*. Because of the large size to which the latter grow—a seven-foot fish has been recorded—long-lining is very profitable, despite the small percentage of successful hooks (about 2 per cent).

Spears

Spearing or harpooning fishes is another time-consuming and primitive method still in use in Kenya. On the lower Athi (Sabaki) river the fishermen work slowly up the banks of the river, plunging the spear down through the reeds and grasses. The chances of success are not very high. In open and clear waters, spears are also used, mainly for large *Clarias*. In Nyanza, where *Clarias* runs up small streams in considerable numbers at night, the fishermen often use spears in preference to basket traps.

Poisons

Fish poisons are used on the lower Athi, particularly in floodwater pools, but they are apparently not used in Nyanza. Graham (1928) reported the use of poisons in the vicinity of Lake Victoria, the poisons being made chiefly from the latex of *Euphorbia*. In some extraordinary way the fishermen of the lower Athi, for example, have discovered that the bark of certain trees (*Mundelea* sp.), when boiled, dried and pulverized, have a lethal effect on fishes. In fact, the bark of this tree contains a very high proportion of rotenone.

Nets

The only indigenous net found in Kenya is the *luora* of the Jaluo of Nyanza Province. The *luora* is a clasp net used either for emptying fishing enclosures or for catching fishes in the rivers. The net, knotted with the universal sheet-bend, and roughly triangular in shape, is tied to two thin sticks about 6 ft. long, the sticks being loosely fastened across the apex. For fishing, the two arms of the triangle are placed over the shoulders or under the armpits, the apex is thrust into the water, and the whole is snapped shut like a purse when lifted. When catching *fwani* below falls, the fishermen stand amongst the rocks or in the river and plunge and lift their nets. The number of successful hauls varies with the season, but when the *fwani* is running a man may take as many as 20 large fishes home with him in the evening.

Imported gillnets are becoming very popular on the rivers, the nets being floated down to catch upgoing migrants. On the rivers of Nyanza it is estimated that nearly 450 tons of *fwani* are caught annually by 5-in. gillnets. Gillnets are highly selective in their catches, only fishes within a certain restricted size range being caught. While this is an advantage in conserving, for example, juvenile stocks, it can sometimes be harmful. Thus in Nyanza the large female *Schilbe mystus* is caught in 2½-in. nets at the mouths of rivers, but the rather smaller male is rarely taken. Exploitation of one sex only is obviously harmful, reducing the chances of successful breeding. Fortunately, this situation does not arise with the *Tilapia* fisheries of the main lake, neither species showing any marked sexual dimorphism as regards size.

Woven Barriers

Although net-making was originally beyond the scope of the Kenya fishermen, presumably through lack of suitable twine, several types of barriers were devised which fulfilled the function of the seine net. One, the *usambo* of the Kavirondo fishermen, was a woven barrier of papyrus matting, about 5 ft. deep, which was pulled like a seine with ropes. Baskets were attached into which the fishes were swept. *Usambo* were not seen during the survey and they may now have been ousted by the illegal but more efficient introduced seine of flax or cotton. A second indigenous seine used on lakes in Nyanza is the *gogo*. Here 6-ft. lengths of papyrus are bent at right angles and strung together so that half floats on the surface and the other half projects downwards, the whole forming a fine barrier about 25 yards long. The *gogo* is pulled in a semi-circle down the beach, either by ropes or by men poling primitive rafts of *ambatch* logs (Plate I). After about 400 yards the two ends of the *gogo* are drawn together and, by pulling out one end, the diameter of the circle is reduced to about 4 ft. The catch is scooped out with baskets and a good haul may yield up to 30 lb. of 2-in. *Engraulicypris*. The fishermen are therefore aware of the pelagic habits of this fish; all other species escape beneath the *gogo*.

An elaboration of this method is found on some of the inland lakes of the Yala swamp. Six-foot rafts of matted papyrus roots are cut from the edges of the lake and are sewn together to make the *gogo*. The *gogo ofunga*, as it is called, is pulled very slowly across the

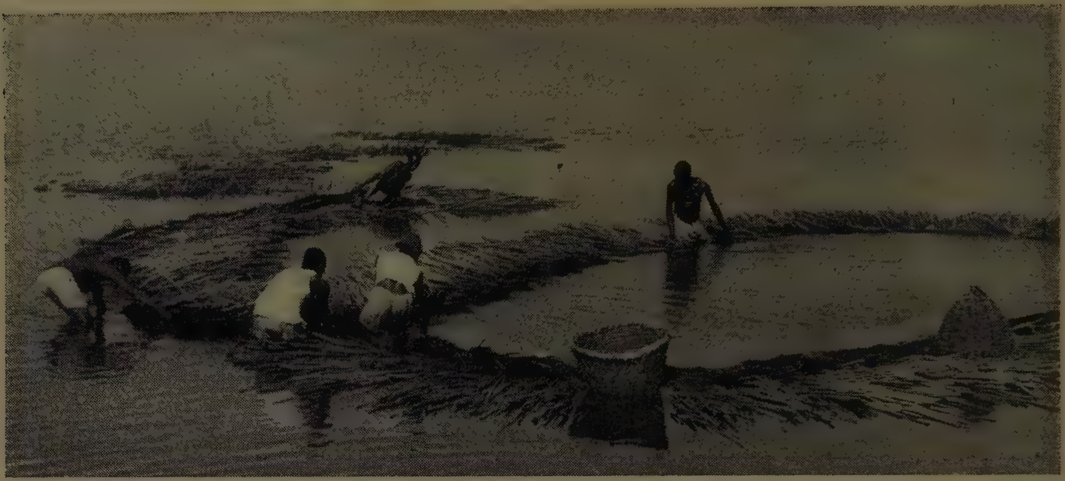

Plate I.—The *gogo*, a primitive type of seine used by the Jaluo fishermen of L. Victoria. Scooping baskets in foreground

Plate II.—A line of *oloch'wira*, or fishing enclosures on the Nzoia River floodplain, Nyanza Province

lake by *ambatch* rafts, and on reaching the shallow water, basket traps are placed across the entrance and the water enclosed by the *gogo* is beaten vigorously with sticks. This type of *gogo* was apparently designed with the rather specialized knowledge that the majority of fishes avoid the deoxygenated conditions found under papyrus swamps and that the dark shadow and trailing roots of the *gogo* appearing above them are sufficient warning.

Enclosures

The fishing enclosure may, historically, have preceded the basket trap, the same principle being used of a non-return entrance but on a larger scale. Known as *oloch'wira,* these enclosures are very common in Nyanza but are not found on rivers to the east of the Rift Valley. The *oloch'wira* is built of 6-8-ft. lengths of papyrus or *Phragmites* bound closely together to form a fence. The enclosure is circular with the two ends folded inwards to form an entrance (Plate II). In some cases a second enclosure is built within the first. The enclosure is emptied either by hand or with a clasp net. *Oloch'wira* are built across channels or depressions in the floodplain where floodwater from the river passes through the larger floodpools where many species spawn. Where the channels open out, ten or more *oloch'wira* may be jointed together to form an impenetrable barrier and row upon row of barriers stretch across the low-lying areas. *Oloch'wira* are designed mainly for the capture of *Labeo* and *Schilbe,* both of which spawn in the floodwater pools. During the floods, sackfuls of fish are exported from the flooded areas, the fish being taken by bicycle to markets ten or 20 miles away. A form of *oloch'wira* is occasionally built across large rivers in Nyanza during the dry season. Catches are high but such barriers are not strong enough to survive the floods and must be rebuilt each year.

Basket Traps

Basket traps reach the height of their development amongst the Jaluo of Nyanza Province, every habitat being exploited with its own type of trap. There are two principle kinds of basket, those which are static and must employ some form of non-return entrance, and the mobile types which have open ends and are used to scoop or enclose the fishes. In the first case the pattern is very old and one that is found repeatedly on all the great rivers of Africa. The traps are cylindrical, about 4-6 ft. long, and are made from thin sticks bound longitudinally over two or more hoops. At one end the sticks are drawn together and tied, and at the other a funnel is inserted (Fig. 1A). The non-return entrances are made with a single strip of wicker-work which, when bound to the perimeter of the basket and given a slight twist, results in a very efficient funnel. This pattern is used both by the Giriama of the lower Athi and the Jaluo of Nyanza. Such traps are usually placed at the edges of rivers amongst the reeds and grasses, but they are also used in combination with the more elaborate types of barrier trap. The baskets are baited on the lower Athi but bait is rarely used in Nyanza. In the former case, maize chaff is boiled down into a paste with which the leaves of *Kedrostris* sp. are mixed. The paste is rolled into balls about the size of a fist and wrapped in castor oil leaves. The castor oil leaves, which prevent the disintegration of the maize ball, are nibbled, probably by river prawns. thus releasing the maize. The *Kedrostris* leaves give off a repulsive smell which is said to attract certain fishes. For Lungfish the traps are filled with water lily leaves since these attract the snails on which this fish feeds. Basket traps depend either on the random movement of fishes, on the attraction of the bait, or sometimes on the active movement of fishes migrating. Catches are, however, usually small since the adults of the large migratory species tend to move in the centre of the river, the smaller species only ascending at the edges. In estuaries a rather flatter type of basket trap is used which is weighted with stones and baited with pieces of fish.

Scooping and enclosing traps follow several designs. In Nyanza Province a type of enclosure basket, the *ihafwa,* is used in shallow swamp areas when vegetation prevents actual scooping. This basket is 2 ft. long and is open at both ends (Fig. 1B). The trap is pushed vertically down into the water and held with one hand. With the other hand the fisherman reaches down through the small hole at the top and extracts the fishes, usually small *Clarias* and *Protopterus*. Like many of the other scooping and enclosing traps, the *ihafwa* is mainly operated by women. In fact it is true to say that all tedious methods, and especially those that catch large numbers of very small fishes, are delegated to the women.

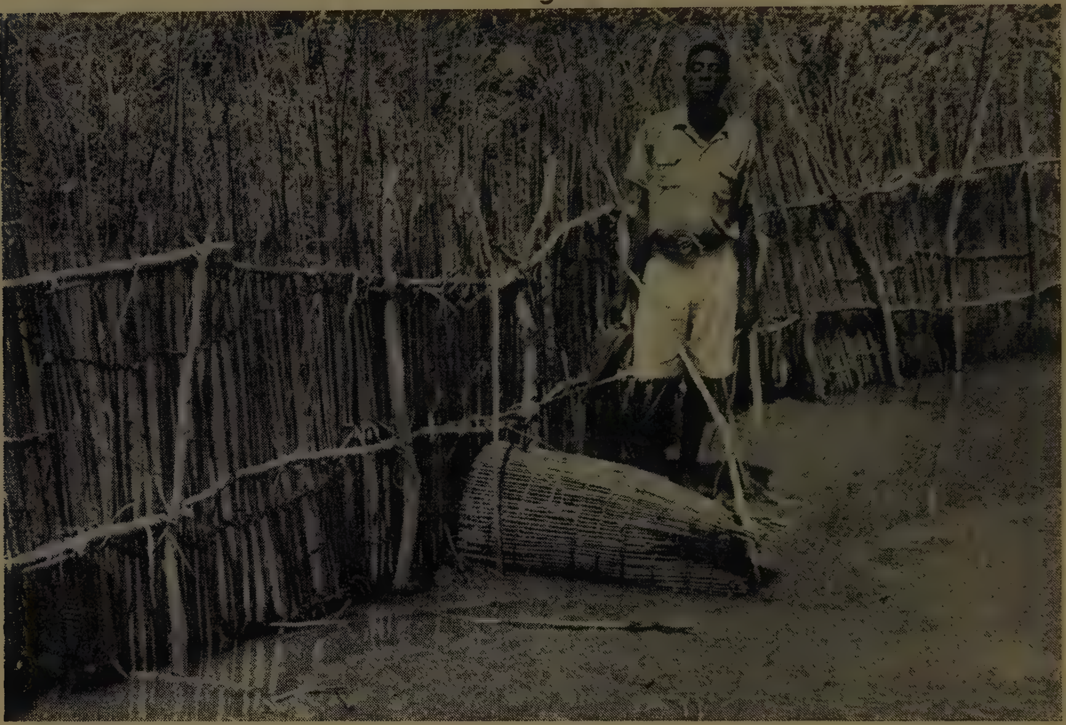

Plate III.—An *uchigo*, a simple type of fishing barrier built by the Giriama of the lower Sabaki River

Plate IV.—A small type of barrier trap (*kek*) commonly used on the Kuja River, South Nyanza

An exception to this is line-fishing, universally the man's prerogative.

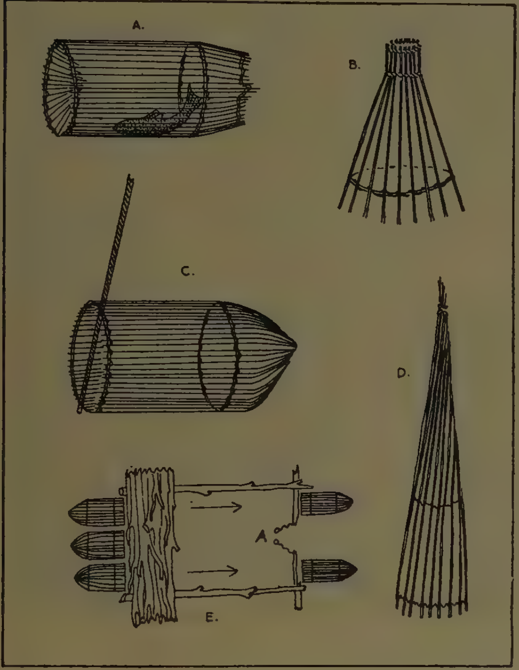

Figure 1.—Various fishing baskets used in Kenya

- **(a) The basic type of basket trap, used singly or in association with barriers.**
- **(b) The *ihafwa* enclosure basket of the Jaluo.**
- **(c) The *olubhango* scooping basket used on the Nzoia River.**
- **(d) The *sienyo* down-stream basket used at Nzoia River *kek*.**
- **(e) Plan of a single *esiguru* enclosure of the Hainga *kek* (Nzoia River). Ascending fishes enter vertical funnel at "A" and are caught in one of the five baskets.**

The true scooping baskets, used mainly for catching small and juvenile fishes, have wide mouths and a fine mesh. They are built round hoops in the same manner as the non-return baskets. In Nyanza the *eseu* baskets, used in floodwater pools, are dragged through dense aquatic vegetation so that the smaller fishes are caught more by entanglement with weeds than by the trap itself. In this way juvenile *Barbus* and *Labeo* spp. down to only 10 mm. in length are caught. During floods a larger scoop is used at the edges of rivers, the *othanzo* or *olubhanzo* of Nyanza (Fig. 1C). The *othanzo* is attached to a pole and is slowly swept down-stream to catch the enormous numbers of small *Barbus* spp. migrating upwards near the banks. Persistence yields about a pound of these small fishes a day.

Barriers

At some in the past it was realized that the effectiveness of baskets could be enhanced by adding barriers on either side so that fishes could be directed into the baskets. This is particularly useful where migrating fishes are concerned. This development has led to the large and striking barrier traps or *kek* of the Jaluo in Nyanza. The simplest type of barrier is the *uchigo* built by the Giriama on the Sabaki river. Here lengths of stiff reeds are bound together at close intervals to form a fence which is placed across small streams. Holes are cut at the bottom and baskets are placed against them (Plate III). The baskets are held in place by sticks driven into the mud and pulled forward over the basket with a length of rope. *Uchigo* are also built across shallow floodwater pools, the barriers being moved progressively as the pools dry out. This latter method seems to have some affinities with the fishing weirs used on the Gambia river (Johnels 1954) and in the Bangweulu swamps (Brelsford 1946). The fishes are caught as they migrate out of the pools and not as they enter. This method is obviously preferable since it allows the adults to spawn first. Similar to the *uchigo* is the *uzio* built by the Giriama in estuaries. The *uzio* is in the form of a "W" with baskets at each point so that fishes are directed in on both the ebb and the flow of the tide.

Another simple type of barrier is that built by the Jaluo on the Kuja river in South Nyanza. A double row of stakes is driven across the river and the gap between them is filled in with stones to form a solid wall (Plate IV). Baskets are placed on the up-stream side or opposite holes in the barrier. Such barriers are however easily overtopped by floods and trapping is therefore mainly concerned with the strip of water confined between two such barriers. In this area the Jaluo also use small V-shaped barriers to divert down-stream fishes into baskets, but these barriers are flimsy and never reach across the river.

It is on the Nzoia river in Nyanza however that the true *kek* are found, enormous barriers built entirely across the river. The largest of all is that at Hainga, about four miles from the mouth of the river. In this stretch the river is 50 yards broad. The barrier is about six feet wide and is made of stout poles driven into the river bed (Plate V). Subsidiary poles, struts and matting are used to divide the barrier into about 40 compartments, each one three to

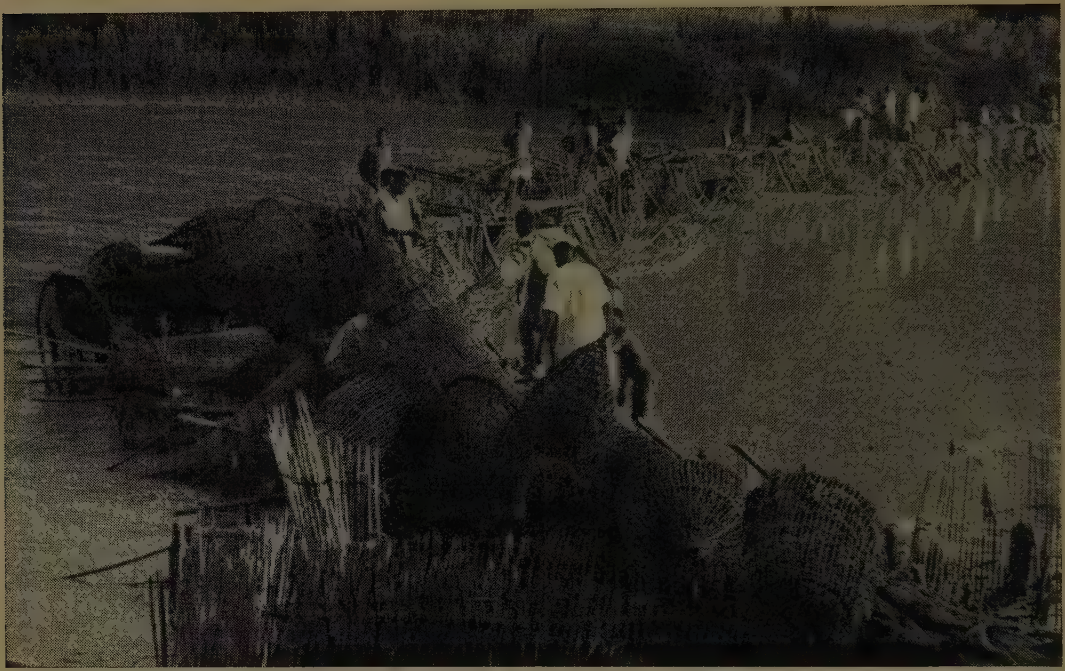

Plate V.—Emptying the baskets at the Hainga *kek* on the Nzoia River, Nyanza Province

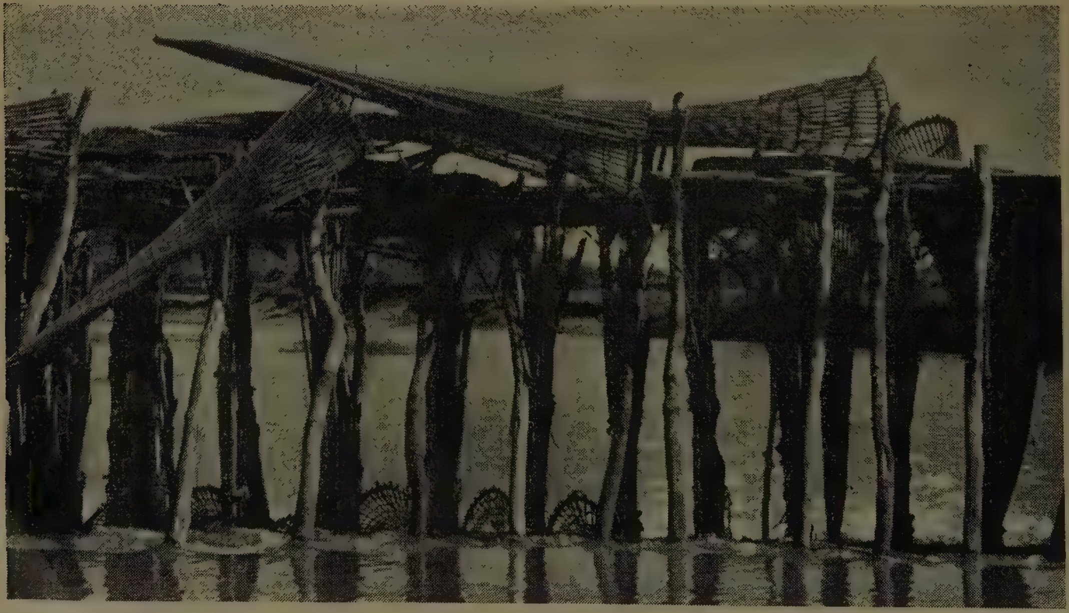

Plate VI.—The Luambwa fishing barrier (looking downstream) and showing *sienyo* baskets in position and drying

four feet wide. Along the up-stream side branches are layed to make a narrow and extremely treacherous catwalk. The entire structure is devoid of nails, being held together only with ropes of sisal and papyrus. The barrier is not straight but bulges slightly down-stream and this, combined with the considerable give allowed to each individual component, contributes largely to the strength of the barrier. With the materials available, a perfectly rigid structure curving up-stream like a dam would snap at the first flood and whole sections would be carried away. As it is, the breakage and removal of the smaller and expendable struts and matting releases much of the pressure on the major poles, so that the main structure is usually unharmed by floods.

The individual compartments, *esiguru,* have a funnel on the down-stream side, on either side of which a hole is cut and baskets placed (Figure 1E). Similarly on the up-stream side three or four baskets are placed, again facing in toward the compartment. These traps have non-return entrances and are not baited. Fishes can only enter the compartment by the funnel on the down-stream side.

At Hainga there are half a dozen narrow *esiguru* which are used only for down-stream trapping. On each side of the river two circular compartments are built, the *esigubali,* which also have a down-stream funnel entrance but rather finer matting walls. The *esigubali* are about eight feet in diameter and, as in the case of the *esiguru,* they have a series of baskets facing inwards. The majority of fishes are however removed by clasp net since the *esigubali* catch mainly the smaller species which tend to migrate in a slow procession near the river banks; such fishes do not readily enter the baskets. Occasionally larger fishes are caught, and netting within the enclosure can be an exciting business if a ten-pound *Clarias* is at large.

The *esiguru* of the Hainga *kek* catch mainly ascending migrants during floods, particularly the *mbiru* (*Tilapia variabilis*) and the *fwani* (*Barbus altianalis radcliffi*). Above Hainga there are other *kek* whose emphasis becomes progessively on down-stream fishes, the cream (and indeed bulk) of the ascending migrants having been taken lower down. One of the highest of the Nzoia *kek* is that at Luambwa, 20 miles up the Nzoia river. Here there are over 200 narrow compartments adapted for down-stream fishes. Behind each compartment a long tapering basket (*sienyo*) is placed

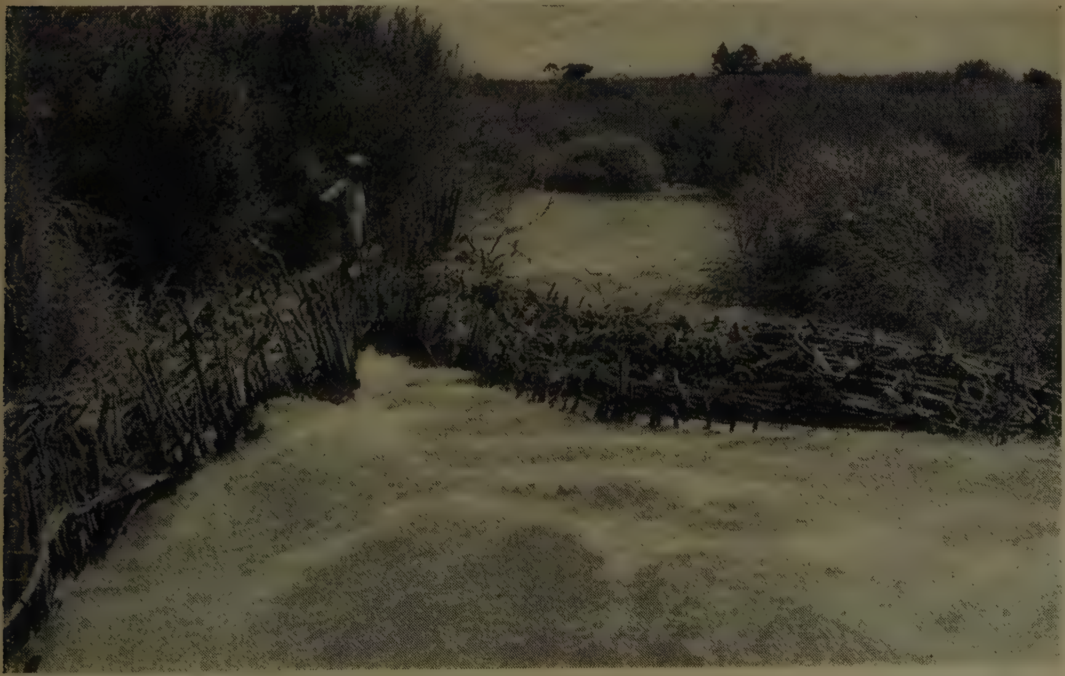

Plate VII.—*Obalalo* **or downstream weir on the upper reaches of the Nzoia River. Fishes are directed into the narrow channel and are stranded**

(Plate VI and Figure 1D). The *sienyo* have no non-return device, the force of the water and the construction of the basket being sufficient to prevent the escape of both large and small fishes. The Luambwa *kek* catches mainly spent migrants which are migrating back to Lake Victoria.

In the upper reaches of the Nzoia river, about 40 miles up-river, the fishermen erect another type of barrier which they call *Obalalo*. *Obalalo* are built on rocky streches of the river where there is a fall of about three or four feet. The fishes are directed into a narrow channel, the bottom of which is filled with stones and acts like seive. Large *fwani* are drawn down the channel by the force of the water and left stranded at the end. Plate VII shows an *obalalo* near Mumias.

The "ownership" of a *kek* is complex and can be compared rather with a co-operative holding than with the more absolute property right exercised in more developed countries. Broadly speaking the two clans (*joka*) farming the land on either side of the river have fishing rights on their own side and this applies to lines, baskets and enclosures. In the case of a *kek* an arrangement is reached by the two clans and the construction of the barrier is undertaken by the men of each. Individual *esiguru* are shared out, one or more to each man, or occasionally one shared between close relatives. Each *esiguru* operative is thereafter responsible for equipping and tending his compartment, replacing poles when necessary and removing debris which accumulates during floods. Catches from the *esigubali* on the other hand are shared out between senior members of the *joka*. Should a man leave the district his *esiguru* is used by another member of his family group, and only exceptionally can the rights of an *esiguru* be bought.

The efficiency of the large barrier traps is in large measure dependent on the free functioning of a host of social ties, customs and obligations. The majority of fishermen would find it difficult for example to abstract the essential principle behind the *kek* organization (which is basically a form of co-operative) from the clan and family organization which generated it. To the fishermen of the Nzoia river the massive *kek* is a tangible (if unconscious) symbol of family ties; the establishment of a co-operative fishing organization reaching beyond clan relationships would be unthinkable to many of the *kek* operatives.

But undoubtedly changes will occur. In the future, irrigation schemes and hydro-electric projects will demand a certain measure of water control and such schemes probably will not tolerate any river obstructions such as *kek*. And the control of flooding will have serious effects on the migrations of river fishes and *kek* catches. Again the erection of barrages and subsidiary furrows will affect the breeding habits of the migratory fishes. Under such conditions the organization of these river fishing industries will be forced to develop along different lines. Thus the well-being, and perhaps survival, of the industry will depend as much on human as on biological factors.

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REVIEW

Breeding Problems and Artificial Insemination, by S. W. J. van Rensburg, published by Libagric, Pretoria, 1957, 249 pp., price 27*s*. 6*d*.

This book, which is well illustrated, is written mainly for farmers who want a general introduction to the subject of breeding and infertility. It is written in simple language and contains a glossary of most of the relevant scientific terms. It is of particular interest in East Africa as it was produced with African conditions principally in view, the section on diseases covering such problems as epivaginitis, which is of particular importance on Kenya farms. The section on the practice of artificial insemination is also of interest as it goes into sufficient detail to be useful to farmers who need to inseminate their own cattle in areas where no organized scheme exists. To sum up it may be stated that this book is one which farmers may confidently buy.

G.H.L.

THE CLIMATIC LIMITATIONS OF SUBTERRANEAN CLOVERS IN KENYA

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In the search for a legume for pastures in Kenya attempts have been made to grow the clover *Trifolium subterraneum*. This clover, which originated in the Mediterranean region, has in many cases more than doubled the carrying capacity of pastures in Australia and New Zealand. In the former country the use of subterranean clover is restricted to the southern half of the continent where winter rains predominate. The clovers germinate with the autumn rains, and make rapid vegetative growth, which is checked, but not stopped, by the low winter temperature; in the spring they flower and set seed before the period of summer drought sets in. Regeneration takes place from these seeds in autumn.

Many varieties with both long and short growing seasons have been selected, but five main commercial varieties are grown:

1. *Early Varieties*. Dwalgunup (first early); Yarloop (second early).

2. *Mid-season Varieties*. Bacchus Marsh (Early mid-season); Mt. Barker (Mid-season).

3. *Late Variety*. Tallarook.

Detailed studies have been carried out to find the exact climatic limits of these varieties. By applying this knowledge to Kenya's climatic data, it should be possible to form an idea of the areas of the colony in which each particular variety is likely to grow.

Trumble (1939), investigating the lower moisture limits of the species, found that growth would continue in any month in which rainfall exceeded one-third of the evaporation from a free water surface. Aitken (1955) carried out a detailed study of the light and temperature requirement for the commercial varieties of subterranean clover, both under artificial conditions and by growing them in different parts of Australia. It was discovered that each variety required a certain amount of cold before flower initiation.

The length of time to which each variety must be exposed to a given temperature before flower initiation will take place is shown in Table I.

TABLE I—LOW TEMPERATURE REQUIREMENTS OF SUBTERRANEAN CLOVER VARIETIES

Variety	Number of months required at the stated temperature before flower initiation will take place with a 12-hour photo-period				
	52°F	59°F	66°F	76°F	77°F
Dwalgunup ..	1	2	4	4½	*
Yarloop ..	2	3	4	*	*
Bacchus Marsh ..	3	3	*	*	*
Mt. Barker ..	3	4	*	*	*
Tallarook ..	3½	4	*	*	*

*Vegetative.

Two points emerge from this study:—

(i) There is a critical upper temperature limit above which a variety remains vegetative and this limit is higher for early varieties than late ones.

(ii) The length of time for which a variety must be exposed to a given temperature is shorter for early varieties than for late ones.

Aitken (*loc. cit.*) also discovered that the period of cold required was reduced under a long photo-period, but in Kenya the photo-period is practically a constant twelve hours a day. There is also some evidence (Aitken, *loc. cit.*) that low nocturnal temperature is more effective in flower initiation than a low diurnal temperature, and this may be of importance in the Kenya Highlands where the difference between day and night temperature is considerable.

By applying the results of the work of Trumble and of Aitken to the climatic data of Kenya, it is possible to state in which areas of the colony subterranean clovers are likely to grow. Rainfall data is available for a large number of centres in Kenya, but evaporation data is limited to eleven widely differing centres. Eight of these are in the Highlands where conditions governing evaporation should be similar.

To obtain evaporation data for a large number of places in the Highlands the correlation coefficient between the mean monthly evaporation and relative humidity at 14.30 hours at these eight centres was calculated. A coefficient of $r=0.785$ was obtained, which for a population of 96 is highly significant, and as $r^2 = 0.6163$, 62 per cent of variability in evaporation can be explained in terms of variations in relative humidity. Using the regression coefficient $b \times y$ in the general formula:—

Evaporation $= 202.57 + 1 - 2.45 \times$ Relative Humidity:—

it is possible to calculate the mean monthly evaporation at all centres in the Highland zone where relative humidity is recorded, giving a total of 26 centres with either actual or calculated evaporation. In addition there are three centres outside the Highland zone for which actual evaporation data exists.

By applying the results of Aitken's investigations in Table I to the climatic data of any locality in Kenya, it is possible to see which locations have sufficiently low temperatures and a growing season long enough for any particular variety to complete its life cycle.

The number of months necessary for flower initiation to take place at a particular temperature for a particular variety, as shown in Table I, must first be allowed. To this period four months at temperatures below 60°F, three months at temperatures between 60°F and 70°F, and two months at temperatures above 70°F must be added to allow for the period between flower initiation and seed setting.

Thus, at Rumuruti, rainfall exceeds one-third of evaporation from March until November, and clovers should grow during this period. As the temperature is below 66°F, but above 59°F during the initial period of growth, the variety Yarloop would take four months to initiate flowers, and should commence flowering in July. From July onwards mean monthly temperatures are between 60°F and 70°F, and flowering and seed setting will take three months and should be completed in September. As the earlier variety Dwalgunup will set seed at higher temperatures in a shorter growing season than Yarloop it could also be grown at Rumuruti. The later variety, Bacchus Marsh, will not initiate flowers at Rumuruti, as temperatures are above 59°F during the whole of the growing season, and this would also be true of the two later varieties, Mt. Barker and Tallarook. (*See* Table II.)

The climatic data for the 26 centres in Kenya for which either actual or calculated evaporation data are available were examined in the same manner. The results of this investigation are summarized in Table III, which shows the latest variety which would set seed at any particular centre. Map 1 is constructed from the same data and indicates the areas in which the different varieties should set seed.

Only the higher and wetter areas of the colony are climatically suitable for subterranean clovers. The late and mid-season varieties will only flower and set seed at the very highest altitudes. The early varieties have a more widespread distribution.

West of the Rift Valley high temperatures are the limiting factor, though north and south of this region drought imposes a limit. Because of a lack of evaporation data it is impossible to show the exact northern and southern limits of the area suitable for subterranean clovers in this region. (*See* Map 1.)

TABLE II—INVESTIGATION OF THE POSSIBILITY OF GROWING DIFFERENT VARIETIES OF SUBTERRANEAN CLOVER AT RUMURUTI

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean monthly rainfall (inches)	0·73	0·92	1·85	3·78	2·25	1·85	3·68	3·62	1·54	1·69	2·89	1·23
One-third mean monthly evaporation (inches) ..	1·66	1·76	1·59	1·31	1·27	1·24	1·08	1·05	1·43	1·47	1·31	1·40
Growing months ..			G	G	G	G	G	G	G	G	G	
Mean monthly temperature	62·9	63·9	64·8	65·2	64·3	63·1	62·0	61·6	62·9	64·7	64·3	63·7
(Latest variety setting seed) Yarloop			X	X	X	X	FS	FS	FS			
(Earliest variety not setting seed) .. .. .. Bacchus Marsh					(Above Critical Temperature)							

NOTE.—G =Growing months (i.e.) mean rainfall exceeds one-third mean evaporation.
X =months during which flower initiation is taking place.
FS=months during which flowering and seed setting are taking place.

TABLE III—CLIMATIC DATA FOR SELECTED CENTRES IN KENYA AND THE LATEST VARIETY OF SUBTERRANEAN CLOVER WHICH WILL SET SEED

Centre	Growing months, i.e. rainfall exceeds one-third of evaporation	Range of mean monthly temperatures during growing months °F	Latest variety of subterranean clover setting seed
*Eldoret	Feb.–Nov.	60·1–64·5	Yarloop.
*Equator	Feb.–Dec.	53·1–58·1	Tallarook.
Kabandori	Oct.–Dec. and Mar.–May	69·5–73·5	None.
Kabate	Oct.–June	61·8–67·1	Yarloop.
Kagumo (Nyeri)	Feb.–Dec.	58·9–65·4	Yarloop.
Kapsabet	Jan.–Dec.	61·8–66·4	Yarloop.
Kiambu	Aug.–Dec. and Feb.–June	63·0–68·9	None.
*Kisii	Jan.–Dec.	66·3–69·2	Yarloop.
Kisumu	Jan.–Dec.	71·1–76·1	Dwalgunup
Kitale	Jan.–Dec.	61·8–67·3	Yarloop.
Machakos	Oct.–May	67·6–69·6	Dwalgunup.
Maralal	Mar.–Oct.	58·9–63·3	Yarloop.
Masara	Jan.–Dec.	70·9–75·0	Dwalgunup.
*Mombasa	Mar.–Jan.	75·4–83·3	None.
Molo	Mar.–Dec.	54·6–58·7	Tallarook.
*Moyale	Oct.–Dec. and Mar.–May	70·3–76·5	None.
*Nairobi (Eastleigh)	Oct.–Jan. and Mar.–June	66·9–69·6	None.
*Naivasha	Mar.–Sept.	60·8–65·7	Yarloop.
*Nakuru	Mar.–Dec.	62·9–67·1	Yarloop.
*Nanyuki	Mar.–Dec.	59·9–63·2	Bacchus Marsh.
*Narok	Nov.–June	60·3–63·7	Yarloop.
Ol Joro Orok	Mar.–Dec.	54·4–58·4	Tallarook.
Rumuruti	Mar.–Nov.	61·6–65·2	Yarloop.
Subukia	Mar.–Dec.	59·8–64·8	Bacchus Marsh.
Thika	Oct.–Dec. and Mar.–May	66·9–69·8	None.
*Voi	Nov.–Dec. and Mar.–May	76·4–80·6	None.

*Centres where actual evaporation data are available.

In, and east of, the Rift Valley, drought imposes a limit to the growth of subterranean clovers. In the Kitui, Thika and Nairobi area there is at least one non-growing month between the two wet seasons, and it is doubtful if subterranean clovers would survive this period. The growing season during the individual wet seasons at the temperatures prevailing is too short to allow the clovers to complete their cycle. In the Machakos area there is a continuous season, and the early variety should set seed.

At the coast temperatures during the growing season are too high to allow even Dwalgunup to set seed. In the Northern Frontier District the growing season is too short.

The conclusions drawn that certain areas in Kenya are climatically suited to subterranean clovers should be treated with caution, as mean monthly rainfall data has been used in calculating the length of growing season. This takes no account of the reliability of rainfall, and in many years the growing season may be too short. A comparison between Map 1 and those of Kenworthy and Glover (1958) for the reliability of seasonal rainfall in East Africa indicates that most of the area suitable for subterranean clovers is in the April to August rainfall area, with a probability of more than 15 in. of rain during this season in eight out of ten years. 15 in. of rainfall are also the minimum considered necessary for subterranean clover growth in Australia.

There are two exceptions:

(*a*) The area between Rumuruti and Maralal where there is a probability of less than 15 in. of rain in one in four years.

(*b*) The Machakos area where there is a probability of less than 15 in. of rainfall in one in three years or even more often.

The possibility of establishing subterranean clovers in these two areas should be treated with caution because of the unreliable rainfall.

Much of the area west of the Rift Valley has a growing season of nine months or more, and it is likely that in these areas a native perennial clover would be much more productive than subterranean clovers, though the latter might prove a valuable addition to a pasture mixture because the thick mat of seed formed in the dry season is valuable fodder for sheep.

This discussion takes no account of the soil factor and subterranean clovers are particularly sensitive to deficiencies of certain mineral elements. It is highly probable that dressing with particular fertilizers will be necessary before subterranean clovers can be established in the climatically suitable areas.

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[2] Aitken, Y. (1955). Flower Initiation in Pasture Legumes. *Aust.J.agric.Res., 6,* 212, 245, 258.

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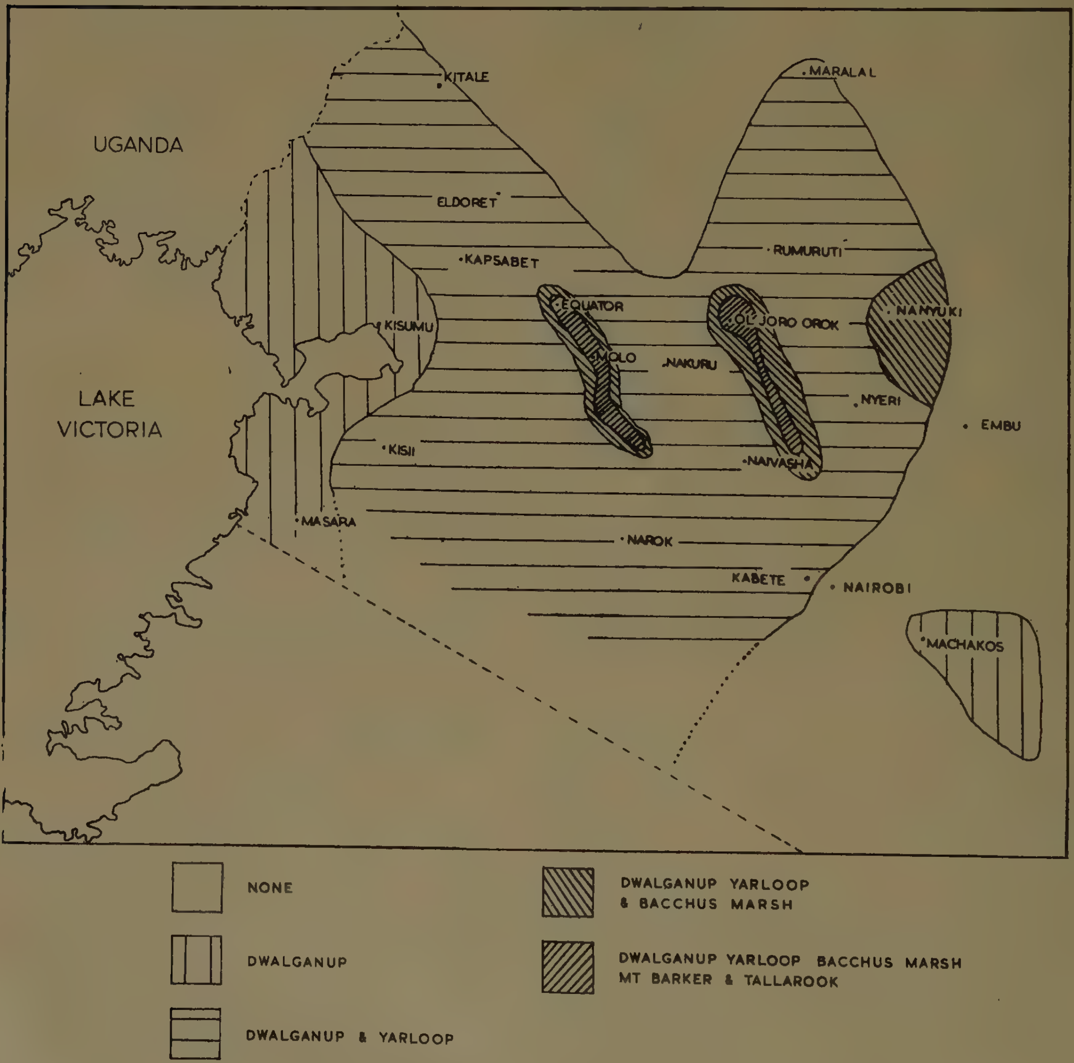
Map 1.—Areas of Kenya climatically suitable for different varieties of subterranean clover

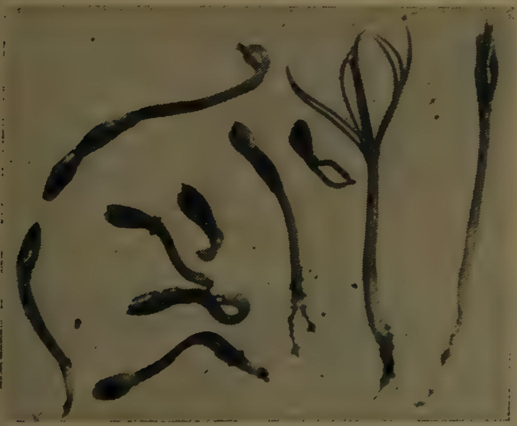


PHYTOTOXIC EFFECTS OF COPPER FUNGICIDES ON ACID SOILS

By I. A. S. Gibson, Forest Department, Kenya

(*Received for publication on 27th August, 1958*)

During 1957 and 1958 reports were received of damage incurred by pine seedlings at the recently established forest stations at Kimakia and Gakoe (South Aberdares). The symptoms of this damage included failure of the rootlet to penetrate the soil of the seed bed with accompanying necrosis of the root tip and curling of the root causing the seedling to fall on its side (Plate I). Under damp conditions death of the root tip did not immediately affect the shoot, which continued to grow for a limited time.



[*Photo*: *M. T. Friend*

Plate I.—*Pinus patula* seedlings showing symptoms of toxic effects of Perenox in acid soils. Note darkening of root tip and curling of rootlet. To the right, two healthy seedlings of the same age are included for comparison.

Tests made on the seed bed soils of Kimakia and Gakoe showed them to be highly acid (pH 4.5—5.0) and it seemed likely that the seedling damage arose from an interaction between these acid soils and Perenox (50 per cent cuprous oxide) which is applied to Forest Department seed beds as a routine prophylactic against damping-off. This hypothesis was tested on a pot scale in the glasshouse using local forest soil acidified to various levels by addition of aluminium sulphate solution. At each level of acidity the survival of *Pinus patula* seedlings was compared in pots receiving Perenox (0.3 per cent suspension applied weekly at one gallon per two square yards) and pots left untreated. The experiment was laid out to a randomized block design. The results (Table I) show that the toxic effects are due to an interaction between Perenox and acid soil. A further similar experiment to compare *Pinus patula* and *Pinus radiata*, the two species most commonly grown in Kenya, showed both to be equally prone to this effect.

TABLE I—VARIATION OF PHYTOTOXICITY OF PERENOX WITH SOIL ACIDITY

TEST SPECIES *Pinus patula* Schl. and Cham.

Approximately 750 *emergent seedlings studied per treatment*

SOIL UNTREATED		SOIL TREATED WITH PERENOX	
Soil Reaction* (pH)	Percentage seedlings with affected rootlets	Soil Reaction* (pH)	Percentage seedlings with affected rootlets
6·0	8·4	6·0	20·9
5·5	5·4	5·6	69·4
5·0	2·5	5·1	85·2
4·5	4·5	4·7	77·4

*Adjusted by the addition of 2, 4 or 8 per cent solutions of aluminium sulphate at a rate of 1 pint per square foot.

Following this, another cuprous oxide formulation, Cuprocide (80 per cent active ingredient) was then compared with Perenox to determine the relative degree to which each became toxic to pine seedlings in acid soils. The results showed that their behaviour was very similar in relation to variations in soil acidity.

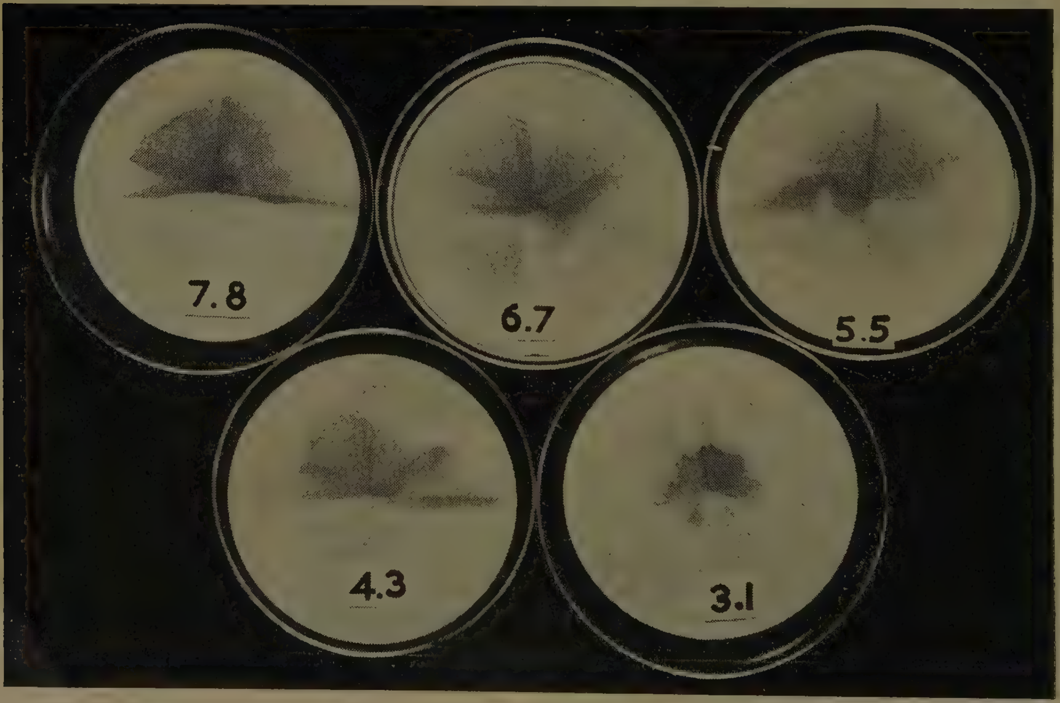
In these experiments the fungicides showed a much higher level of toxicity in neutral soils than was observed in the field or in previous experiments (Gibson 1955; Gibson 1956), and it is thought that this may be due to the use of rather old stocks of Perenox and Cuprocide. Both had been stored in well-stoppered bottles for three years. Some support for this idea was obtained later when an earlier experiment was repeated with a fresh supply of Perenox. Only 8.0 per cent damage was found at a soil pH of 5.6 and nil at a pH of 8.0.

An attempt was made to demonstrate the liberation of copper ion in acid seed bed soils from Kimakia and Gakoe. Samples of these and also of neutral forest soil were set up over small plugs of cottonwool in large glass funnels. 250 ml. of a 0.3 per cent suspension of Perenox was poured into each sample and the liquid draining out from each funnel was collected. The effluent from the acid soils was clear and showed no trace of Perenox in suspension, but a deposit of Perenox could be seen just below the surface of the soil in the funnel. On the other hand that from the neutral soil could be seen to carry Perenox in suspension, and no layered deposit was formed beneath the soil surface. Controls, in which water was passed through soil samples, were included in this series.

Tests were made for copper in the effluent from the Perenox-treated acid soil using zinc dibenzyldithiocarbamate reagent in carbon tetrachloride, but no more copper was found in this solution than was present in effluent from untreated acid soils, the controls. It was not possible to perform similar tests on the effluent from neutral soils as the suspended Perenox could not be entirely removed from it, a necessary preliminary to the acidification required for this test.

As no copper could be demonstrated in the extract from the acid soil, it seemed possible that the toxic effects might be due to the action of root secretions on the layer of cuprous oxide formed in the acid soil following Perenox treatment. A test for sufficiently acid root secretions was made by germinating both unsterilized and surface-sterilized (0.1 mercuric chloride) seeds of *P. patula* and *P. radiata* on water agar containing bromo cresol green indicator. No root excretions more acid than pH 5.0 were produced.

So far no direct evidence had been obtained to account for toxic interaction of acid soils and Perenox. As it seemed possible that copper might be liberated in the soil under acid conditions, but held by the clay fraction, the solubility of Perenox suspensions in buffered solutions was tested at a range of pH values. These were made up from a B.D.H. formulation based on that of Prideaux and Ward (1926) and adjusted to values of 7.8, 6.7, 5.5, 4.3 and 3.1. To 50 ml. of each buffer solution 10 ml. of a 0.3 per cent suspension of Perenox was added and the mixture allowed to stand for 10 minutes. It was then filtered and the deposit on the filter examined. The filter deposit was progressively less with increasing acidity and corresponded with a decrease in turbidity of the filtrate, indicating that some of the Perenox passed into solution in the acid conditions possibly yielding sufficient soluble copper to account for toxic reactions observed. The variation in filter deposit is shown in Plate II.



[*Photo*: *C. Spinage*

Plate II.—Deposits obtained from filtration of mixtures of Perenox with buffered solution of different pH values. Each deposit is marked with the pH value of the mixture from which it is derived

SUMMARY

Some limited experiments have indicated that toxic reactions of pine seedlings to cuprous oxide fungicides, when growing in acid soils, may be due to copper liberated in the soil solution. Cuprous oxide fungicides ("Perenox", "Cuprocide"), tend to be deposited near the surface of the acid soil and toxic copper may accumulate in the region of the germinating seed. There is some evidence that old stocks of these fungicides are more likely to give toxic effects than fresher supplies. Similar toxic effects might conceivably arise from the interaction between acid soils and other metallic fungicides.

ACKNOWLEDGMENTS

I would like to thank Mr. M. T. Friend for assistance in the copper analyses and Dr. F. M. L. Sheffield for kindly reading the typescript.

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REVIEWS

METHODS OF WEED CONTROL, by Earl A. Helgeson, F.A.O. Agricultural Studies No. 36, published by F.A.O. Rome, Italy, 1957, 189 pp., 32 figs., price 10*s*.

This book deals mainly with chemical methods of weed control, although cultural and mechanical methods are also reviewed. The author has summarized the latest information and experience (at the time of writing) in a form which will be of great value to the farmer and the agricultural officer, who must have great difficulty in selecting the right herbicide for a particular purpose. Equipment for weed control is described in considerable detail; the control of aquatic weeds, of woody plants, and of weeds in grassland and turf is discussed in three of the sections; and the field crops in which weed control is considered include wheat, maize, cotton, forage legumes, rice, sorghum, soyabeans, sugar cane and Hevea rubber. Horticultural crops are given a large section in relation to weed control, and 41 weed species are considered individually in regard to their reaction to herbicides. A most useful Appendix gives the susceptibility of many hundreds of plant species to 2,4—D, 2,4,5—T, MCP, DNC, and DNBP, summarized in tabular form. This is a revision of "Weed Control by Growth-regulating Substances", which was published by F.A.O. in 1951, and periodic reviews of this subject will be of great assistance to agriculturists throughout the world.

D.W.D.

AN ATLAS OF AIRBORNE POLLEN GRAINS, by H. A. Hyde and K. F. Adams, published by Macmillan & Co., London, 1958, 112 pp., + xvi, 10 × 7 in., price 36*s*.

Mr. Hyde is well known to all palynologists and indeed to most British botanists for his quantitative work on airborne pollens carried out during a long period of years. As a result of this work he has naturally become highly competent at recognizing pollen grains and his present atlas makes his knowledge available to the public. The atlas contains descriptions of the pollen of 92 species and each is illustrated by two to four photographs, The photographs are excellent, as they have to be, since even photographs of ordinary standard are useless for pollen identification, and the grains have been expertly prepared. Since palynologists have developed a highly complicated set of specialized morphological terms the short glossary at the end is very necessary. The key at the beginning is competently put together and appears to be usable by anyone.

This atlas, which is produced on excellent art paper, is obviously mainly of interest to medical people concerned with allergies; its main use will be in Britain and when used with caution in other parts of the northern temperate region. Only two or three species which occur in Africa are mentioned so the book is of limited value here save as a pattern of how things should be done.

B.V.

THE CONTROL OF AMBROSIA BEETLE ATTACK ON LOGS

By S. J. Curry, Kenya Forest Department

(*Received for publication on 27th August, 1958*)

Ambrosia beetles are responsible for the common type of timber defect in the tropics known as pinhole damage. They attack freshly felled logs and unhealthy living trees, boring into the sapwood and often penetrating into the heartwood. An adequate moisture content of the wood, which, it is generally agreed, must exceed 40 per cent, is an essential characteristic for the occurrence of attack. This is essential for the growth of the Ambrosia fungi, which are cultivated by the beetles in their galleries to provide food for themselves and their larvae. The typical dark staining of the wood at the periphery of the old galleries is due to this fungal growth as shown in Figs. 1 and 2. Most of the frass produced by the beetles as they bore into the wood is ejected by them at the log surface as shown in Fig. 2 and is often aggregated in short strings in dry weather as in Fig. 3.

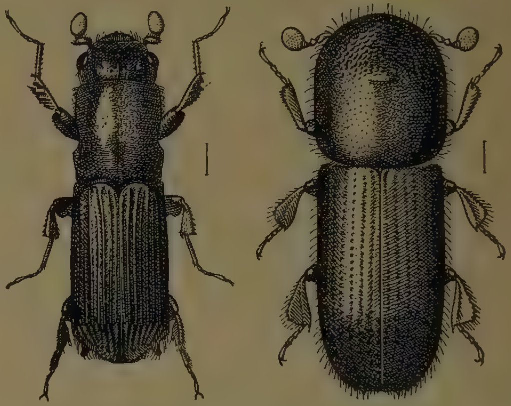
Beetles of the family Platypodidae and some genera of the family Solytidae form this group of timber pests. Typical examples of Platypodid (*Platypus* sp.) and Scolytid (*Xyleborus* sp.) beetles are illustrated in Fig. 1.

Ambrosia Beetle Damage in Kenya

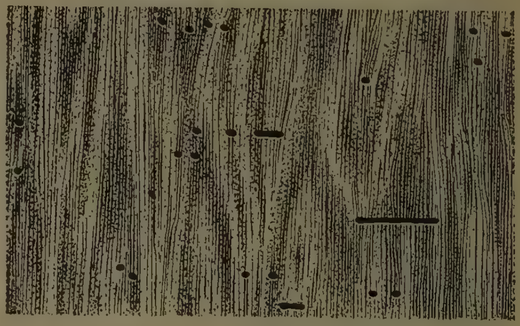
As a result of a survey carried out in the main forest areas of Kenya, it was found that though the occurrence of these beetles is widespread from sea-level to over 9,000 ft., damage to felled logs is comparatively important only in those areas which are characterized by warm humid climatic conditions and an altitude of less than 7,000 ft. Insecticide trials were carried out in the following four areas where this damage is common:— Meru and Nyeri in the vicinity of Mount Kenya and Kakamega and Nandi near Lake Victoria.

One tree species, *Olea welwitschii*, is particularly susceptible to attack, both in the log and in over-mature standing trees, at Meru and Nandi, and to a lesser extent at Kakamega. One Platypodid species, *Symmerus montanus*, is almost entirely responsible for the damage at all three places. *Olea welwitschii* logs were used in the first insecticide trial at Meru, but owing to the difficulty of obtaining easily accessible logs of this species at the other places, other common susceptible species were used at later trials. It was also discovered that damage to the heartwood of over-mature trees was so common at Nandi and Meru, that felling and conversion of *Olea welwitschii* ceased to be economically worth while.

Fig. 1



Platypus sp. *Xyleborus* sp.



Typical dark stained galleries

Trials of Insecticides

It was decided to begin by testing insecticides containing the gamma isomer of Benzene-hexachloride (B.H.C.), which had previously been reported as being much more effective than D.D.T. by Thompson in the Gold Coast [1] and by Browne in Malaya [2].

In all the following trials the bark was retained on all logs because of labour difficulties and the increased costs involved in removing bark of thickness exceeding 1 in.

Previous small-scale experiments with *Olea welwitschii* logs had shown, however, that logs with the bark removed showed significantly less attack than those with the bark retained. Attack of the cut ends of the latter was concentrated in the cut surface of the bark and there was a definite tendency for galleries, after penetrating the sapwood for 2 in. to turn outward to the bark again. This would appear to indicate that the bark possesses definite attractive properties.

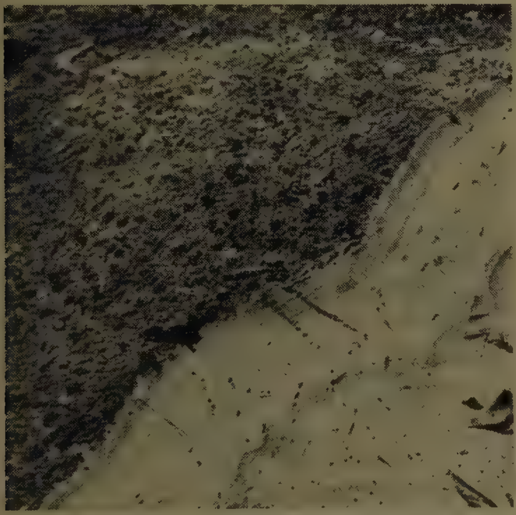


Fig. 2.—Attack on *Olea welwitschii* log showing frass on bark and dark stained galleries in wood

Fig. 3.—Short strings of frass ejected from holes in bark

The following standard experimental method was used in all seven trials:—A number of trees of the largest convenient size were felled and cross-cut into logs of equal length, ten being selected for each treatment and the untreated control, to give approximately equal surface areas exposed to attack in each case. The logs were then marked and scattered at random in a forest clearing, or in one case a sawmill yard, close to other attacked logs or trees. In all cases the logs were shaded as far as possible. The insecticides were applied by spraying as soon as possible after the trees were cross-cut, so that the total surface area was completely wetted. The general rate of application to ensure complete wetting was one gallon of insecticide per 100 sq. ft. of surface area. Statistical analysis of a comparison of the mean rates of attack per treatment was carried out at the end of each trial.

Trial No. 1.—At Meru, Upper Imenti Forest, altitude 5,200 ft., using *Olea welwitschii* logs, 6 ft. long, 2 ft. mean diameter, 44 sq. ft. mean surface area. One proprietary insecticide, diluted in diesolene to give a concentration of 1 per cent gamma B.H.C. was compared with untreated controls. Cost of treatment per 100 sq. ft. of surface, excluding labour, was Sh. 4/40.

Attack of untreated logs began within 24 hours of cross-cutting. The Emergency conditions prevented frequent inspection of the logs but the results of the three detailed inspections as given in Table I, show that treated logs remained free from attack for the first seven weeks at least, and only very slight attack occurred during the next ten weeks of comparatively dry weather. Even during the following 21 weeks of wet weather, only negligible attack compared with that of the untreated logs, took place. Damage by termites and other insects was also prevented during the same period.

TABLE I—MERU—*Olea welwitschii logs*
(Mean surface area 44 sq. ft.)
Mean No. Holes per sq. ft. of Log Surface (Cut ends only)

Weeks after treatment	Treatments: 1% gamma B.H.C. in oil	Un-treated	Rain-fall	Run-ning total
7	0	18	3″	
17	0·48	44	4″	7″
38	1·11	60	15″	22″
Mean No. Holes per sq ft. of Log Surface (Through bark)				
7	0	16	3″	
17	0	54	4″	7″
38	2	113	15″	22″

Trial No. 2.—At Nyeri (Kiganjo), Keith Timber Co. Sawmills, altitude 5,700 ft., using *Ekebergia rueppelliana* logs, 6 ft. long, 1 ft. 6 in. diameter, mean surface area 32 sq. ft. The insecticide tested at Meru was compared with another cheaper proprietory insecticidal emulsion, diluted in water to give a concentration of 1 per cent gamma B.H.C. Cost of treatment per 100 sq. ft. surface area, excluding labour, was Sh. 3/05.

Results of three detailed inspections are given in Table II. There is no significant difference between either treatment and the untreated mean attack, or between the two treatments. There is some indication of initial attraction of attack by both treatments however, and the oil solution does appear to have a greater residual effect than the emulsion. Removal of the bark at the end of the trial showed that other borers had attacked all but eight of the 30 logs, six of these being treated with the oil solution and two with the emulsion. These borers were of the families Cerambycidae and Buprestidae.

TABLE II—NYERI—*Ekebergia rueppelliana logs*
(Mean surface area 32 sq. ft.)
Mean No. Holes per sq. ft. of Log Surface
(Cut ends and through bark)

Weeks after treatment	1% B.H.C. in oil	1% B.H.C. water emulsion	Un-treated	Rain-fall	Run-ning total
3	0·65	1·06	0·47	2"	
10	1·06	1·42	2·00	2½"	4½"
31	1·43	2·28	3·90	10½"	15"

Three species of Platypodidae were responsible for the main damage to the logs—*Doliopygus nairobiensis, Doliopygus serratus* and *Triozastus propatulus.*

Trial No. 3.—At Kakamega forest, altitude 5,500 ft. using *Celtis soyauxii* logs, 6 ft. long, 1 ft. 6 in. mean diameter, 32 sq. ft. mean surface area. The same two insecticides were used as in the previous trial, but the concentration of gamma B.H.C. was increased to 2 per cent, because of the conflicting results then obtained. Cost of treatments per 100 sq. ft. surface area, excluding labour, was Sh. 6/60 for the oil solution and Sh. 6/10 for the emulsion.

Results of inspections over a period of nine months are given in Table III. After eight weeks and 13 weeks, both treatment means are significantly less than the untreated mean attack, but the treatments only show a significant difference between themselves at the later inspection. This shows that the solution in oil has a greater residual effect and the trend continues throughout the period of inspection, during which the rainfall was uniformly high.

TABLE III—KAKAMEGA—*Celtis soyauxii logs*
(Mean surface area 32 sq. ft.)
Mean No. Holes per sq. ft. of Log Surface
(Cut ends and through bark)

Weeks after treatment	2% B.H.C. in oil	2% B.H.C. water emulsion	Un-treated	Rain-fall	Run-ning total
8	0·12	0·19	2·4	10"	
13	0·15	0·56	3·3	11"	21"
24	1·35	3·00	7·7	18"	39"
36	2·42	4·40	9·0	21"	60"

Some 20 species of beetle attacked the logs, including ten *Doliopygus,* three *Platypus,* two *Trachyostus,* three *Periomatus,* one *Symmerus* and one *Xyleborus* spp.

Trial No. 4.—At Nandi forest, altitude 6,500 ft., using *Croton megalocarpus* logs 5 ft. 6 in. long, 1 ft. mean diameter, 19 sq. ft. mean surface area. This trial ran concurrently with the previous one, to compare the efficiency of the same insecticide in oil at a concentration of 2 per cent gamma B.H.C., on two different tree species.

Results of inspections are given in Table IV. Attack of the treated logs is significantly lower after eight weeks but not at later inspections, though the treatment does afford some protection throughout the period of inspection. Its effectiveness does not seem to be quite as good as in the previous test, though statistically the difference is slight.

TABLE IV—NANDI—*Croton megalocarpus logs*
(Mean surface area 19 sq. ft.)
Mean No. Holes per sq. ft. of Log Surface
(Cut ends and through bark)

Weeks after treatment	2% B.H.C. in oil	Un-treated	Rain-fall	Run-ning total
3	0·02	0·07	2"	
8	0·05	0·29	9"	11"
13	0·13	0·33	7"	18"
22	0·20	0·60	15"	33"
39	0·25	0·93	22"	55"

Fourteen species were responsible for the attack of the logs: including five *Doliopygus,* four *Platypus,* two *Trachyostus,* two *Symmerus* and one *Periomatus* spp. Eleven of these had been found attacking the logs in the trial at Kakamega.

Trial No. 5.—At Nandi forest, using *Croton megalocarpus* logs, 7 ft. long, 1 ft. 6 in. mean diameter, 37 sq. ft. mean surface area. This trial compared a different proprietory B.H.C. oil miscible insecticide, with a B.H.C. dust used as a suspension in water, both with a gamma concentration of 2 per cent. The latter is the cheapest form of the insecticide but is more easily washed off by heavy rain. Cost of treatments per 100 sq. ft. surface area excluding labour, was Sh. 9/40 for the oil solution and Sh. 4/60 for the suspension in water.

Results of eight months inspections are given in Table V. Both insecticides show significant differences at the 1 per cent level, from the control, throughout the period and though there is no statistically significant difference between them, the suspension in water gave the longest complete protection from attack.

TABLE V—NANDI—*Croton megalocarpus logs*
(Mean surface area 37 sq. ft.)
Mean No. Holes per sq. ft. of Log Surface
(Cut ends and through bark)

Weeks after treatment	2% B.H.C. in oil	2% B.H.C. suspension in water	Un-treated	Rain-fall	Run-ning total
4	0·005	0	0·3	7"	
7	0·005	0	0·7	6½"	13½"
11	0·005	0	0·9	10"	23½"
20	0·016	0	1·9	6½"	30"
32	0·016	0	3·1	12½"	42½"

Trial No. 6.—At Nandi, using *Polyscias kikuyuensis* logs 7 ft. long, 1 ft mean diameter, mean surface area 24 sq. ft. The same insecticides used in the previous trial were compared at lower gamma concentrations, 1 per cent and 0.5 per cent in oil and 1 per cent in water, with a proprietory emulsion in two forms, in water and oil, each with a concentration of 1 per cent Dieldrin. Costs of treatment, per 100 sq. ft. excluding labour were:— 1 per cent B.H.C. in oil Sh. 5/85; 0.5 per cent in oil Sh. 4/10; and 1 per cent in water Sh. 2/30; 1 per cent Dieldrin in oil Sh. 4/95; and 1 per cent in water Sh. 2/90.

Results of inspections are summarized in Table VI. During the first 12 weeks all treatments except 1 per cent Dieldrin in oil were significantly different from the untreated controls but not between themselves, all giving effective protection. At later inspections 1 per cent Dieldrin in water showed reduced effectiveness followed by 1 per cent B.H.C. in water. Finally, at 44 weeks, the two treatments of B.H.C. in oil showed the least deterioration in efficiency.

Eleven species of Platypodid beetles attacked the logs:—Five *Doliopygus* spp., three *Platypus* spp. two *Symmerus* spp., and one *Trachyostus* sp. Ten of these species also attacked the Croton logs of Trial No. 5.

Trial No. 7.—At Nandi, using *Polyscias kikuyuensis* logs, 6 ft. long, 1 ft. mean diameter, mean surface area 20 sq. ft. The concentration of Dieldrin was increased to 2 per cent in both emulsions and compared with four insecticides containing gamma B.H.C. Of these, the powder suspension at 1 per cent B.H.C. and the oil solution at 1 per cent B.H.C. were as in the previous trial and a log paint prepared with water at 1 per cent gamma B.H.C., with another oil solution of 1 per cent gamma B.H.C. with tar additives, were also included.

Costs of treatment per 100 sq. ft. surface area, excluding labour, were:— 1 per cent gamma B.H.C. as water suspension Sh. 2/30, and in oil solution Sh. 5/85; in oil solution with tar additives Sh. 5/35 and as a paint at 1 per cent Sh. 11/20; Dieldrin 2 per cent in oil cost Sh. 7/75 and in water Sh. 5/80.

TABLE VI—NANDI—*Polyscias kikuyuensis logs* (Mean surface area 24 sq. ft.)
Mean No. Holes per sq. ft. of Log Surface (*Cut ends and through bark*)

Weeks after treatment	Dieldrin 1% in oil	Dieldrin 1% in water	B.H.C.			Untreated	Rainfall	Running total
			1% in oil	0·5% in oil	1% in water			
4	0·04	0·06	0·01	0·03	0·02	1·39	4½"	
8	0·30	0·17	0·02	0·04	0·06	4·54	5½"	10"
12	0·74	0·37	0·05	0·04	0·07	7·26	6½"	16½"
24	1·02	0·80	0·14	0·16	0·36	10·96	15"	31½"
44	1·13	1·99	0·19	0·30	1·49	12·65	10½"	42"

Results are summarized in Table VII. All treatments except 2 per cent Dieldrin in water gave effective protection for the first eight weeks, but after 12 weeks only 1 per cent B.H.C. as a suspension in water and as a solution in oil with tar additives, remained effective, the latter showing the best residual efficiency at the end of 24 weeks.

DISCUSSION AND RECOMMENDATIONS

The effectiveness of gamma B.H.C. was demonstrated in all trials except the second. The anomalous result in that trial was probably due to the bias caused by very high attack of two logs of each of the two treatments. If these were omitted from the statistical analysis the treatment means would be significantly less than the untreated mean. The odd results could have been caused by incomplete coverage of those logs due to irregular shape and rough bark. One reason for the exceptional duration of control by 1 per cent B.H.C. in oil at Meru may be the fact that only one beetle species was involved and possibly exceptional properties of absorption of the insecticide by the bark. An unexpected result was the efficient protection afforded by the B.H.C. powder as a suspension in water, which gave comparable results to the solutions in oil at both 1 per cent and 2 per cent gamma concentrations, despite consistently high rainfall during the early stages of the last three trials. Dieldrin emulsion proved to be less effective, at the same concentrations, than gamma B.H.C.

Thus, for the normal expected maximum period that control of Ambrosia attack should be required, i.e. from two to three months, the simplest and cheapest insecticide, which will also give efficient results, is the B.H.C. powder suspension in water. During dry weather a 1 per cent gamma concentration @ Sh. 2/30 per 100 sq. ft. surface area is recommended, in wet weather a 2 per cent concentration @ Sh. 4/60 per 100 sq. ft. If logs are likely to remain in the forest for periods in excess of three months during wet weather, an oil solution of 1 per cent gamma B.H.C., preferably with tar additives, would be expected to give adequate protection for from four to six months in local conditions, @ Sh. 5/35 per 100 sq. ft. of surface.

ACKNOWLEDGMENTS

I wish to thank the Foresters and other members of their staff who so ably assisted in these trials at the four forest areas concerned, and also the staff and management of the local sawmills who assisted with the preparation of the logs, etc.

I am also indebted to Imperial Chemical Industries Limited, for permission to reproduce Fig. 1 from their booklet "Gammexane Products" and to Mr. C. Spinage for his help with the other illustrations.

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TABLE VII—NANDI—*Polyscias kikuyuensis logs* (Mean surface area 20 sq. ft.)

Mean No. Holes per sq. ft. of Log Surface (*Cut ends and through bark*)

Weeks after treatment	Dieldrin 2% in oil	Dieldrin 2% water	B.H.C.				Untreated	Rainfall	Running total
			1% in oil	1% in oil with tar	1% in paint	1% in water			
4	0·09	0·18	0·10	0	0·08	0·06	1·78	7"	
8	0·12	0·25	0·11	0·01	0·14	0·06	2·85	4"	11"
12	0·16	0·28	0·12	0·01	0·20	0·06	2·95	3"	14"
16	0·23	0·45	0·21	0·01	0·49	0·11	3·84	1¼"	15¼"
24	0·31	1·38	0·43	0·05	3·06	0·65	7·00	1½"	17"

HERBAGE PLANTS AT SERERE EXPERIMENT STATION, UGANDA 1954–57—II: LEGUMES

By **C. R. Horrell, Agricultural Department, Uganda**

(*Received for publication on 27th June, 1958*)

This is a brief account of the legumes studied during the last three years in nursery plots at Serere. The main object of the study has been to find suitable species for use in leys; at the same time those possibly suitable for green manuring have been noted. In a previous paper (Horrell, 1958), which dealt with grass species, the geographical position and environment of Serere Experiment Station were described. The arrangement of this paper follows that of its predecessor, and those legumes which have been studied in most detail are again starred in the text.

TRIBE GENISTEAE

Crotalaria incana L. SR.5412 Tropics and Subtropics

An annual green manure crop which makes rapid growth and is palatable and non-toxic to cattle. It can produce up to eight tons per acre of green matter in 10 weeks. It seeds well but the pods are heavily infested with pests and the seed harvesting is generally poor. It will pollard if cut back before flowering.

Crotalaria juncea L. Sunn hemp. Tropics and Subtropics

Sunn hemp has been used for years at Serere as a green manure crop in certain long-term experiments. It grows rapidly to 3 ft. to 4 ft. high and flowers at five to six weeks old. It seeds heavily but, like other *Crotalaria* spp., is heavily attacked by pod-borers.

Lupinus angustifolius Eastw. SR.5513, 554 Mediterranean

Rapid germination is obtained with lupins but subsequently growth becomes very slow, the roots are attacked by nematodes, and the base of the stems are attacked by termites. The plants wilt badly during even short dry spells and eventually die out after a useless existence.

Lupinus luteus Linn. SR.5518, 5512, 559 Mediterranean

This behaved similarly to *L. angustifolius* and is quite useless.

TRIBE GALEGEAE

Indigofera spicata Forsk (=*hendecaphylla* Jacq.) SR.5453 E. Africa. Creeping-Indigo

This low-creeping perennial is one of the commonest local legumes. It nodulates well. An indigenous strain was tested in mixture with Rhodes grass under grazing conditions. Owing to its small and prostrate habit it contributed little to grazing; it is, however, palatable to both cattle and to poultry. Once established it maintains itself and will still come back from seed long after the original stand has been ploughed out. It seeds prolifically. Germination is very much increased by thorough scarification (e.g. from 10 per cent to 70 per cent). Reports from elsewhere on the toxicity of this plant were not confirmed when 10 per cent by weight of dried leaf was added to a standard mash and fed to baby chicks.

Indigofera hirsuta L. SR.5746 and SR.5748 Pan Tropical

This is perennial and a heavy seeder but rather stemmy and of little agronomic interest.

Indigofera subulata Vahl. ex Poir (Syn. I. retroflexa Baill.) SR.5416 E. Africa

This species is easy to establish, produces abundantly in its first year and makes good recovery after cutting, but begins to die out in the second year and by the end of three years the stand is very poor. It is less palatable than many legumes. Seed production is good. At Serere it was being considered for use in a two-year ley until recently when it was found to be host to a nematode which may also parasitize cotton and other crops.

Indigofera tettensis Klotz. SR.5415 E. Africa

A very unpromising annual which is small and unproductive.

Tephrosia subtriflora Hochst. SR.5439 E. Africa

This is a semi-prostrate, softly pubescent perennial which is unproductive and considered useless for pasture.

Tephrosia sp. SR.5440 E. Africa

A woody perennial shrub which grows to about 5 ft. high, and when sown thickly in a row produces an attractive garden hedge.

Tephrosia ehrenbergiana Schweinf. SR.5441 E. Africa

This is an unproductive perennial which begins to die out rapidly in its second year. It seeds profusely but is of no value for leys.

TRIBE HEDYSAREAE

Arachis prostrata Benth. S. America

This is a small perennial which produces an excellent ground cover. It is prostrate and stoloniferous, with short internodes. A few flowers are produced but no seed is set. The plant is too small and unproductive for pasture but could be considered for soil cover in perennial crops. It nodulates well and showed a marked response in growth to an application of gypsum

Alysicarpus glumaceus DC. SR.541 and others. E. Africa

This is a small semi-prostrate annual. It seeds heavily after three months and then dies out. It is unproductive and does not withstand competition well. When seeded in a pasture it contributes virtually nothing to the grazing and soon disappears.

Alysicarpus vaginalis DC. SR.5532 Alyce clover. Asia

This is a perennial which loses its leaves in the dry season. Seeding is heavy but it is unproductive as a herbage plant.

Alysicarpus rugosus DC. SR.5533. Tropics

This small annual is a heavy seeder but is unproductive and dies out after six months.

Aeschynomene americana Linn. SR.5745 Tropical America

This annual rapidly produces strong, deep roots thickly covered with small dark red nodules. It grows 4 ft. to 5 ft. high, flowers after two months and seeds heavily. The plant is woody with tiny leaves and is no use for grazing, though it might be a soil improver.

Ornithopus sativus Gren. and Godr. SR.538 and 5422 Seradella: Mediterranean

This plant grows only a few inches high and flowers sparsely; it is out of its environment at this altitude in the tropics.

**Stylosanthes gracilis* H.B.K. SR.492 Stylo. S. America

This is the most vigorous and aggressive legume yet introduced. It is sub-erect, perennial, hairy, with small leaves and a rather high proportion of stem. It flowers and seeds strongly, is easily established and in a few years becomes widespread in neighbouring plots from self-sown seed. Stylo is a strong colonizer on dry eroded hillsides, in dense *Paspalum notatum* swards, on murram patches, etc. Grown in combination with grasses, it has been shown to be too aggressive for Rhodes grass but is more manageable with the stronger growing Guinea grass and *Hyparrhenia rufa*. Stylo is grazed; it is not so palatable as most of the grasses with which it is grown, but is more palatable than many other legume species. It is very drought-resistant, continues growth long after other species and remains green throughout the dry season. It nodulates well, producing a mass of small dark-red nodules. There are indications that it will fix nitrogen; this is being tested further. It is killed out by fire but regenerates readily if it has been allowed to seed itself before burning. Stylo is a most promising species both here and under harder conditions where other legumes are unsuccessful.

Stylosanthes sundaica Taub. SR.5433 Townsville lucerne. South Africa

A tiny ephemeral which seeds a few weeks after sowing and then dies out.

Teramnus sp. nr. *labialis*. SR.5522. E. Africa

This is a small creeper and twiner, which forms a tangled carpet 3 in. to 4 in. deep in the wet season, but sheds its leaves during dry spells and is killed out by the prolonged annual drought. It produces seed but does not reseed itself easily. Under Serere conditions it shows no promise for pasture.

Desmodium canum. (Gmel.) Schinz. Thell. SR.5473. Tropical America

A small prostrate plant which produces seed heads on erect stems 6 in. to 12 in. high. It is unproductive.

Desmodium discolor. Vog. SR.576 South America

This perennial produces a single erect woody stem up to 6 ft. high in six months. It flowers after four months but seeding is not prolific. The leaves are large and pinkish in colour. It is of no use for pasture or as a fodder plant.

Desmodium intortum Urb. SR.5474 Tropical America

A vigorous perennial which produces long trailing stems, rooting at the nodes. It is very productive and can be grazed. It begins to flower in May and continues throughout the season. Seed production would be moderately good but for Meloid beetles which eat the flowers. It carries little foliage in the dry season, when most of the leaves drop and form a mulch.

Desmodium limense Hook var. *sandwicense* SR.5559 Tropical America

This perennial was obtained from Ceylon where it is considered a promising pasture plant. It grows well but shows no advantage over *Desmodium uncinatum* which is more productive and which, in habit is fairly similar.

Desmodium triflorum DC. Pan-Tropical: E. Africa

A small indigenous perennial which is very common locally where grass is short. It grows well in association with *Paspalum notatum* on lawns and also on very thin poor soils in dry situations. It is extremely palatable to poultry and to baby chicks in particular.

**Desmodium uncinatum* Jacq. SR.5476 and SR.5477. Tropical America

This is a semi-prostrate perennial which is one of the most promising pasture species at Serere. It is vigorous, seeds profusely, stands defoliation well, is rapid in recovery from grazing, is fairly palatable and is productive. It nodulates freely without inoculation. Dry season production is poor, however.

Lespedeza cuneata G. Don SR.565 Sericea. Asia

This grows only to 1 ft. high in six months and production is poor. It seeds a little. It barely survives the dry season and with the following rains there is very little growth.

Lespedeza stipulacea Maxim. SR.5417. United States

In the United States this is an important cultivated annual but at Serere it behaves as a tiny ephemeral which grows 2 in. to 3in. high, seeds after 10 weeks then rapidly dies out. It might be worth trying again if inoculated with the correct Rhizobium strain.

TRIBE TRIFOLIEAE

Medicago denticulata Willd. SR.5419 Mediterranean

A small unproductive annual which seeds and dies out after five months.

Medicago hispida Gartn. var. *confinas*. Gaertn. SR.5420 Mediterranean

A tiny ephemeral which is of no value here.

Medicago sativa L. Lucerne. Near East

Provence, Hairy Peruvian, Booberowie, Hunter River and Saladina varieties have been grown successfully in 3 ft. rows which were kept cultivated. No yield measurements have been taken but productivity appears to be fairly good. Leaf spot is occasionally evident but not severe. Flowering is normal but only shrivelled, worthless seed is produced because of attack by a Myrid pest. Recovery from cutting during the rains is rapid. It appears that Lucerne could be grown at Serere for special purposes if circumstances warranted it.

Melilotus alba Desr. SR.5418, 555, 558, 5511 Asia Minor

Cape Sweet, Hubam and Bokhara clover introductions have been made. Early growth of these is rapid and productive, and lush cover crops result in three months from sowing. Hubam makes the best progress, but few plants of any of the varieties survive the dry season. A small amount of seed is formed by all the varieties. Further work with this species might be worthwhile if there was a need for a short-term legume in the rotation.

Trifolium species

The species listed below were tested, some of them several times and all gave poor results with the exception of subterranean clover. (The latter grew well but failed to seed.)

T. alexandrinum Bory and Chaub. SR.5436 Berseem. Near East

T. baccarinii Chiov. SR.5557

T. hirtum All. SR.5619 Rose clover

T. fragiferum L. SR.5618 Strawberry clover Europe

T. rueppellianum Fres. SR.5435, 5525 Rueppell's clover E. Africa

T. semipilosum Fres. SR.5438 Kenya white clover E. Africa

T. steudneri Schweinf. SR.5437 E. Africa

Trifolium johnstoni Oliv. SR.5484 Kenya Purple Clover E. Africa

T. subterraneum Linn. Subterranean clover Europe (nine varieties tested)

T. tembense Fres. SR.5482 E. Africa

It has been argued that further trial of these under ameliorated soil conditions might give better results. It is possible that some of them may inherently be better nitrogen fixers than many of the stronger growing legumes from other genera. Until now, however, none of them have been considered worth including in agronomic trials. Species of this genus belong either to high altitudes in the tropics or to higher latitudes and it is unlikely that they can be grown here except under very artificial conditions. Simpson (1958) reports, however, that *T. semipilosum* and Louisana White Clover, *T. repens*, Linn., grow successfully at Kawanda near Kampala. There the soil is better and temperatures are generally lower.

TRIBE PHASEOLEAE

Cajanus cajan Millsp. Pigeon pea SR.5767

This was grown as a possible forage legume. It is an indigenous perennial which nodulates well and is said to be an excellent soil fertility builder. It produces a mass of foliage and it pollards when cut to 18 in. high but is killed by cutting to ground level. It grows to a height of 6 ft. in the first season and produces a thick woody stem. It seeds prolifically but the pods are heavily infested with a variety of pests. It is sometimes infested with eelworm. Further north, in Uganda, where the ravages of pests are less severe it is widely grown as a pulse crop. The species should be investigated further as a soil improver, food crop and producer of dry season fodder and grazing.

Canavalia ensiformis D.C. SR.535 Sword bean. Tropics

This is an erect woody plant which grows to 2 ft. high in two months, then flowers and produces a heavy seed crop in three to four months from sowing. When left over the dry season it first sheds its leaves, sprouts new foliage and then produces a second seed crop with the "grass rains" in February. The seed is a large white bean. Sword bean is potentially a useful crop for both man and livestock.

Centrosema pubescens Benth. SR.5534 S. America

This was introduced to Serere many years ago and is now naturalized. It is an aggressive perennial climber which also thrives well without support. It is slow in early establishment but after about two months, grows rapidly and soon forms a complete ground cover. It flowers four months after sowing and produces a fairly heavy seed crop. It can be grazed and is very leafy though the stems are tough and wiry. It is drought-resistant. It is a difficult plant to eradicate since after digging or ploughing in it will shoot again from the tap root that is left in the ground.

Clitoria ternatea L. SR.5446 Kordofan pea. Tropical Asia

This is a slender perennial climber with sometimes a bushy habit, growing about 2 ft. tall and producing attractive blue "pea" flowers. It is quite productive in the first year but declines thereafter. This decline may be associated with a rootknot eelworm with which it becomes quite heavily infested. It withstands grazing and cutting. It is used as an ornamental in gardens in Uganda.

**Glycine javanica* L. SR.5414, 564 Old World tropics: E. Africa

Glycine is a perennial creeper which is indigenous and fairly common locally. It seeds well generally; the flowers are pollinated by bees. It is palatable, stands grazing, is very drought-resistant and is fairly productive at the latter end of the year when other species stop growth. Establishment and early growth are slow.

One strain produces an excellent cover in four months. Another, from a commercial source in South Africa, is much less vigorous and does not compete well with weeds. Strain selection needs to be carried out as this is a promising pasture species.

Phaseolus lathyroides Linn. SR.539 Phasemy bean. Queensland

This is an erect bushy biennial which becomes somewhat woody when mature. It is palatable, seeds profusely, and makes rapid growth. Recovery from grazing is not good, however, and it suffers the disadvantage of root nematode attack which can be very heavy. Whether this nematode could be a pest to following crops is not yet known.

Pueraria phaseoloides Benth. SR.5447, SR.5612 S. Asia. Tropical Kudzu

Kudzu is a perennial prostrate or climbing herb which roots at the nodes. It produces excellent bulk in the rains; in the dry season it sheds many of its leaves and in pure stand is self-mulching. Seeding is fair but the seed needs thorough scarification before sowing. It is too early to report on its reaction to grazing, but it is palatable to cattle. Being a vigorous bulky legume which climbs when given the opportunity, it should compete well in mixture with tall fodder grasses. A strain from Australia (SR.5612) is visually better than one obtained from Trinidad. This is a very promising species.

Dolichos spp. Tropical

Several introductions of Dolichos spp. have been made. None showed any promise for pasture. The flowers of *D. lablab* L. are heavily attacked by pests which prevent seeding. *D. falcatus* Klein. SR.5413 is reported to be a perennial but did not survive the dry season and few flowers were seen and no seed produced. *Dolichos* sp. var. *Kilima Kiu* from Kenya grew well for two years until it was ploughed out. This species also produced very few flowers and no seed. When tried as a ground cover under bananas it was unsuccessful in the dense shade.

Mucuna sp. SR.5453 and others. Velvet bean. Tropics

This annual bean has a growing period of four-and-a-half to seven months according to variety. It produces a great bulk of very succulent forage and can be used as a green manure. Very large irregular-shaped pink nodules are formed. Heavy seed crops are produced. It is possibly a good legume for use in mixture with tall fodder grasses either for silage or for dry season grazing. It may be one of the better nitrogen producers since benefits to following crops are often reported.

Vigna gracilis (Guill. and Perr.) Hook f. SR.5442 E. Africa

A perennial which quickly produced a dense cover from delicate prostrate creeping stems which root at the nodes. It was not observed to flower and was killed out during its first dry season.

Vigna parviflora Planch. SR.575 Tropics

This perennial twining plant is poor in production and unpromising.

Vigna oblongifolia A. Rich. SR.5443 E. Africa

An annual twining plant which was not vigorous, seeded only shyly and is considered of no agronomic interest.

TRIBE VICIEAE

**Calopogonium orthocarpum* Urb. SR.5310

This is a vigorous perennial vine-like plant which roots at the nodes and rapidly produces a dense ground cover. It is very productive throughout the rainy season but loses its leaves in the dry season and forms a mulch. At Serere many of the plants die out during the dry season but vigorous growth is produced from self sown seedlings the following year. It has been grown in mixtures with several grasses for four years, and has maintained itself very satisfactorily over that time. Seed production is heavy and seed harvesting by hand is less laborious than with some other species. Calopo is palatable to cattle. This legume is considered one of the most promising yet tested.

DISCUSSION

Among the legume species tested so far, the most successfully adapted ones for growing under local conditions (without fertilizers) are:—

> *Stylosanthes gracilis, Calopogonium orthocarpum, Centrosema pubescens, Desmodium* spp., *Pueraria phaseoloides, Glycine javanica.*

All these are successful when grazed in a mixed sward and the general tendency is for the proportion of legume in such sward to increase from year to year. Establishment from seed is not such a problem as in the case of grasses.

It will be noted that all of these species, with the exception of *Glycine javanica,* are exotic and also that South American species predominate. On the other hand, in the case of grass species tested so far, it has been shown that the most useful ones for leys are indigenous. It is also seen that these useful legumes all fall in the two tribes *Hedysareae* and *Phaseoleae* except for *Calopogonium orthocarpum* which is a member of the *Viceae.*

Many potentially useful species remain to be tested and, it is felt that the genus *Desmodium* in particular, is worth further exploration. This work has already demonstrated, however, that a number of tropical legumes are capable of vigorous growth and reproduction in the Serere environment. This environment includes a soil possessing low pH, organic matter, base status, phosphorus and sulphur content and although total rainfall is high, distribution is only moderately good, water retention capacity of the soil is low and there is a fairly severe dry season of three months duration.

Future work must take cognisance of the point that is emphasized by some people that on low fertility soils, apparently unadapted exotic species may be grown successfully with the aid of fertilizers. This may mean that legumes like lucerne, *Melilotus alba* and others will come to the fore. The needs and resources of a still primitive peasant agriculture must be kept in view however and one of the desiderata at the present time in the north and east of Uganda, is a good nitrogen-fixing legume which will function on poor soils without fertilizers. Work on nitrogen fixation which is now beginning at Serere is necessary to show whether such an ideal legume can be found.

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REVIEW

BIRD HYBRIDS, by Annie P. Gray. Technical Communication No. 13 of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh. Published by the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1958, 390 pp., price 50*s*.

In this book all the available information on bird hybrids has been collected and collated as a check-list and bibliography. Although this is a work of reference for the serious ornithologist, the author has included popular names wherever possible, so that even the fledgling amateur may find that part of the book which interests him. Great care has been taken to enable the reader to assess the authenticity of any particular cross, and the bibliography of 78 pages reflects the thoroughness with which the book has been compiled.

D.W.D.

THE EAST AFRICAN CAMPHOR FORESTS OF MOUNT KENYA

By **M. F. H. Abraham, Forest Department, Kenya**

(*Received for publication on 28th May, 1958*)

Mount Kenya, with its snow-covered peaks, lies on the Equator and is situated about 100 miles north-east of Nairobi. A belt of forest at an altitude of between 6,000 and 9,000 feet extends all the way round the mountain, except for a small timberless gap on the northern slope. The forest belt falls into two main vegetation types which are related to the moisture conditions found on Mount Kenya.

The first, and the one which will be considered here in more detail, is a high-moisture type, with an estimated annual rainfall of from 50 to 90 inches. This forest type is confined to the southern and eastern slopes of the mountain. It is sometimes known as Tropical Mountain Forest, and is largely dominated by *Octoea usambarensis, Podocarpus milanjianus,* and some 20 other commercial broad-leaved species [1, 5].

The second, a lower-rainfall type, is composed chiefly of *juniperus procera, P. milanjianus* (at higher altitudes), *P. gracilior* (at lower altitudes), *Olea hochstetteri* (East African Olive) and numerous other species.

The wetter forest region may be divided into three types:—

(i) Lower altitudinal-type forest, which is found located mainly in the bulge of the south-east corner of the mountain, and along river banks on the southern slopes.

(ii) The camphor forests themselves, which lie from 6,000 to 8,000 feet. They are found in characteristically broken country, which has a gentle south to north incline with numerous ridges and steep valleys.

(iii) The bamboo forest, which is replaced at 11,000 feet by moorland vegetation—the last 1,000 feet being fairly steep country.

The camphor forests of Mount Kenya are as yet undeveloped, but they constitute a major asset to the Colony's forest estate. Exploitation within the area has been carried out on an insignificant scale, and has been confined to the removal of dead, dying and mature trees. No working plan has been written, nor have any systematic ecological or botanical investigations been carried out. However, a few scattered sample plots have been measured, and together with observational surveys some conclusions of a general nature can be drawn. European knowledge of the camphor forests is limited, and it was only in 1948 that a permanent forest station was set up within the area.

From the few details hitherto available it is evident that there is a discrepancy in girth classes. The ratio of mature and over-mature trees to those between the sapling and mature stage has always been thought to be very disproportionate. The data given in Table I, quantitatively expressed, confirms this conjecture.

TABLE I—QUARTER GIRTH CLASSES

Girth Class	No. of Trees in Sample Plots	Percentage
Up to 1″ ..	11,824	76·27
2″ to 4″ ..	1,860	11·99
5″ to 12″ ..	1,240	7·99
13″ to 20″ ..	462	2·99
Over 20″ ..	120	0·76
	15,506	100·00

It can also be shown that present-day conditions are no longer favourable for the camphor to maintain itself by constant regeneration. The existing old trees must have established themselves under conditions different from those obtaining today. Definite information as to what those conditions were is not available. Hutchins [3] in 1907, noted "that there is a fair show of suckers; seedlings are rare or absent; and there are no trees in the pole stage". Little detailed observations or experimental work has been done since then to study camphor regeneration. It has been dismissed as an insoluble problem, or wild elephant have been blamed for prevention or regeneration by eating the suckers and seedlings.

The wet south-eastern forest never becomes sufficiently dry to burn, whereas in the south-west the fire danger is very real. Serious damage has been done by the illegal practices of honey-hunters, who carelessly set fire to the forest when smoking out bees to collect honey. Due to fires we find that in 1906 parts of Aberdare Range were reported to be diminishing at the rate of half-a-mile per year. Evidence that the same sort of destruction has taken place in the camphor forests is shown by elderly honey-collectors being able to point out sites where certain tribal rituals used to take place. These sites are now one to two miles inside the forest, and yet used to be several hours march from their homes, situated on the then forest boundary. Mass destruction in recent times has indeed been considerable.

A picture of the three different zones of forest in this moist area of Mount Kenya shows that the marginal forests, found from 4,800 to 6,000 feet, are located along the fringes of the forest boundary and in the south-eastern bulge. This bulge was no-man's-land in tribal warfare days, and was saved from complete destruction as has been the case in other places. In 1920, the "bulge" became temporary *shambas* and most of the tall trees were left standing—10 to 20 yards apart. The *shamba*-land was subsequently abandoned and it soon became colonized by a dense woody growth. The present vegetation supports this evidence.

The second zone, the camphor forests, located from 6,000 to 8,000 feet, constitute economically the important area. Besides *Ocotea usambarensis* and *Podocarpus milanjianus* there are many commercial species. Where the forest is cut up into many narrow ridges camphor is found growing on the top, or, more frequently on the edges, of each ridge. Above an altitude of approximately 7,200 feet the camphor stocking is found to be higher than in similar forest below that altitude. A distinctive emergent canopy layer at 120 to 160 feet is followed by an almost continuous layer at 60 to 110 feet and a lower shrub storey at 10 to 25 feet. The shrub storey is composed almost exclusively of *Rubiaceae* species. Climbers are present and ferns are commonly found on rough-barked camphor and *Xymalos monospora*. There is no well-developed vegetation on the forest floor, since little light manages to penetrate through the upper canopies.

The bamboo forest, the third zone, occurs above 8,000 feet. The lower bamboo forest is extremely dense, interspersed with isolated *Podocarpus* trees and is intersected by elephant and buffalo tracks. Epiphytic mosses are common on the trees and bamboo canes. In the upper bamboo areas, the forest is broken up by glades, in which numerous high montane and alpine species grow. Here the bamboo dominates.

Before any serious experimental work can be carried out on the camphor forests of Mount Kenya, a knowledge of the flora of the area is required. To date, some 300 plant specimens have been collected, many of which are now being identified, and from these a start can be made on a check-list [4].

In order to find whether the camphor forests are homogeneous two main observational survey lines were cut by the writer through the area, and sample plots of half-an-acre in size were taken at regular intervals along these lines. From data obtained it was seen that the abundance of commercial species varied, although the precise reasons for the heterogeneity cannot at present be defined. But, in any case, with these sample plots it was possible to distinguish three types within the camphor forests: secondary growth forests, river valley forests, and ridge top forests.

The secondary growth forests show in many areas, a succession from abandoned *shamba*-land to a climax vegetation. The *shamba*-land is soon covered with bracken and herbs, and as the bracken rhizomes are nearly always present in the ground they re-establish themselves rapidly. Next follows quick growth by *Triumfetta* and woody herbs. *Macaranga* then comes in on the woody litter, and with its rapid growth, eventually dominates the herbs, bracken and *Triumfetta*. A canopy, and pure crop of *Macaranga* is soon formed. In one particular area, which was cultivated in the past, a good stocking of young camphor is now on the ground. At some time they must have suckered profusely, been allowed to get away, and now the stocking in this area is greater than in the natural forest.

Although no figures are available for the river valley forests, the valleys are characterized by unstable soil, frequent windfalls and a preponderance of light-demanding species. Wild bananas, mosses and tree ferns also abound.

The ridge-top forests contain the main commercial species and all the camphor forest.

Since it is important to know whether the camphor is maintaining itself by constant regeneration, a sample plot of 22 acres was marked off in a typical area of camphor forest, and a complete enumeration of 13 acres was carried out. Girth class enumerations by species were recorded separately for each individual acre and for each ten-yard square plot within each acre. Notes on the habitat——open canopy, closed canopy, density of field layer, etc.——were also recorded for each ten-yard square plot. A summary of the girth class enumerations is given in Table II. From the data obtained from this one sample plot, it was apparent that the camphor was not maintaining itself by constant regeneration.

The conditions for regeneration of camphor must be known if the silvicultural conditions of the species are to be understood. Observations were made on clearings inside the forest and on areas of abandoned cultivation, and from these observations it was noted that many species do establish themselves, but thereafter conditions do not always appear favourable for their combined survival. Some species can germinate in the full shade of the forest floor, whereas others require considerable light, and, in most cases, a definite gap in the canopy. If *Macaranga* is present in large numbers in the initial colonization then it will invariably suppress any camphor by its more rapid growth. In 1950 and 1951 experiments to reproduce camphor vegetatively from tree and sucker cuttings and from suckers were unsuccessful, but in 1952 and 1953, Mr. T. A. M. Gardner [2] found that there was in fact profuse camphor regeneration produced annually under the fast growing *Macaranga* secondary regrowth. He removed the rubiaceous middle storey, girdled large unmerchantable trees, cut creepers and thinned out the young *Macaranga*. The camphor seedlings survived when this treatment had been carried out, and many thousands of wildings were planted in the Embu nursery, shaded for a period, and successfully planted out to enrich the natural forest devoid of camphor regeneration.

Camphor obviously requires light for regeneration and the absence of more vigorous competitors to establish itself. These conditions are rarely encountered within the forest and are, in the writer's opinion, responsible for the serious discrepancy in the girth classes found for this species.

Although the conditions found in some areas of the camphor forests appear suitable for initial germination, they are clearly not suitable for the final establishment of camphor. This leads one to believe that some catastrophic event in the past must have taken place to have caused the establishment of camphor forests. When camphor trees are felled they usually sucker profusely, and having regard to the evidence already stated, it is suggested that cultivation be used to aid the establishment of the suckers in the initial stage. Comparison may be made with the establishment of Mvule in Tanganyika.

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TABLE II—QUARTER GIRTH CLASSES

	Up to 1″	2″–4″	5″–12″	13″–20″	Over 20″	Total
Ocotea usambarensis	109	—	—	—	20	129
Cassipourea elliottii	1,803	117	83	23	2	2,028
Podocarpus milanjianus	199	82	165	87	10	543
Olea hochstetteri	147	17	—	10	15	189
Apodytes dimidiata	42	15	11	12	17	97
All others	9,524	1,629	981	330	56	12,520
						15,506

OBSERVATIONS ON THE FLOWERING OF EXOTIC PASTURE GRASSES IN KENYA

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The introduction of exotic grasses for use in the high altitude and high rainfall areas of Kenya brings various problems, generally becuase the day-lengths and temperatures on the Equator are very different to those of the countries from which the introductions are made. For example, the cocksfoots and ryegrasses are mostly imported from Northern Europe and the Antipodes, and many of these introduced strains are physiologically ill-adapted for producing seed, or even good yields of herbage, in Kenya conditions of short day-lengths and absence of a cold, winter period. But by choice of a suitable strain the local grazier can avoid using a grass which runs to seed and he can be in the enviable position of having a ley which produces all leaf and no stem. In the long run, however, there is little doubt that local selection and breeding from strains of the imported grasses would be worth while.

It is well known that strains within a species can differ in their day-length and temperature requirements for growth and the induction of flowering. The present simple observations were therefore made at the Molo Grassland Research Station (altitude 9,000 ft., latitude 0° 25′ S.) to add to the information already known on the variation in flowering, and on other important factors such as rust resistance and seed shattering, in imported grass strains.

Experimental Method

To economize in seed, and labour requirements, 12 ft. rows of each strain were sown. In 1956 four replications were used (randomized blocks), two of them being cut at the hay stage in 1956 and thereafter periodically to provide data on persistency. The present observations were made on the remaining two replicates. In 1957 the strains, mostly ecotypes from the F.A.O. collection, were sown unreplicated, but spaced plants were used as well as row sowings. Spacing was two feet between rows in all cases. The seeds were sown direct in the field with a dressing of one cwt. per acre of triple superphosphate in the drill. The percentage germination of the seed lots was unknown but with few exceptions field germination was good, the same volume of seed being sown for all strains of one species giving a seed rate of approximately 20 lb. an acre in seven-inch rows.

Results are expressed as the day of emergence of the first panicle in a row, from the day of sowing; this gives an indication of the earliness of the strain. Emergence was recorded once a week. Counts of the number of panicles exserted in a yard length, in the centre of the 12 ft. rows, were also done; these give an idea of the seed production potentials of each strain.

Because most of the results are based on a single season's work, it is necessary to know if there is a cumulative or carry-over effect of day-length and temperature on the competence of a strain to flower, from one season to another. Little work has been reported on this subject, but it has been shown (Cooper, 1952) that with an early and a late strain of perennial ryegrass the influence of the previous season may be neglected. With other species, however, such as Beta (Hamner, 1942), and Hyoscyamus (Long and Melchers, 1943), a persistent and cumulative effect has been noted.

Because the plot size was small and the replication limited or none, it is useful to have some idea of the variation in the time of flower emergence and in panicle numbers which might be expected under local conditions within any one strain. It is difficult to assess this in the present work because the variation will necessarily reflect the genetical homogeneity or otherwise of each individual strain, and suitable replication for one strain might not do for another. However, in 1957, 11 rows of New Zealand "Grasslands" cocksfoot and six rows of Danish commercial cocksfoot were included among the other single-row cocksfoot strains. With the former, the mean time of emergence from sowing was 149 days with a range of from 133 to 160 days (s.d. ± eight days for any day within this range); with the latter the mean was 128 days with a range of from 119 to 133 days (s.d. ± eight days). It is clear that considerable variation can occur between rows of the same strain and it would be unwise here to classify the cocksfoot strains too rigorously into early and late flowering strains. In fact, they were classed for convenience arbitrarily into early (emergence 100 to 133 days from sowing), and late flowering strains (emergence 134 to 194 days from sowing).

The means of the panicle counts for the above strains were 2.2 panicles (range 0 to 5) for "Grasslands", and 31 panicles with a range of from 20 to 50 (s.d. ± 9.8) for the Danish cocksfoot. A count of nine rows of second year S26 cocksfoot gave a mean of nine panicles a yard with a range of from 1 to 20, and the mean of 12 rows of S24 perennial ryegrass was 2.7 panicles with a range of from 0 to 5. Considerable variation can thus occur.

The level of nitrogenous manuring is the main factor under experimental control which might be expected to influence the results. Nitrogen does not influence the date of emergence (Evans and Calder 1931), but it can greatly affect tiller production and hence the number of flowering heads (Evans 1954, Cooper 1948 and 1951). When however, the photo-period or temperature conditions limit flower induction and emergence there is an indication that with cocksfoot (Gardner and Loomis 1953) the level of fertilization does not, as might be expected, affect the number of panicles produced. No nitrogen was applied in the present work.

RESULTS

Cocksfoots

Tables I and II summarize the data. To reduce tabulated matter the results from the F.A.O. collection of ecotypes are grouped as frequency classes within each country of origin.

Great differences are evident in the times of flowering among the bred strains. The quickest strain was St. 22 from Italy which flowered 119 days from sowing. The latest strains flowered 194 days from sowing and three strains did not flower at all. Nearly all in the F.A.O. collection were early flowering.

A similar diversity is shown by the panicle counts, ranging from none to up to 148 panicles a yard, among the bred strains. Most of the F.A.O. collection flowered more profusely than the bred strains. As might be expected the late flowerers had generally fewer panicles than the early, but this may reflect merely the date of counting. Counting was done when it was thought that any flowers which would emerge afterwards would be unlikely to set seed because of the dry wheather which set in at that time. Two counts were done, however, in 1956 on a block of nine American cocksfoots and the results are shown

TABLE I—BRED COCKSFOOT STRAINS

Strain	Origin	Days from sowing		No. Panicles/yd.
		to Flowering	to Panicle Count	
	Early Types			
*St. 22	Italy	119	160	60
Potomac	U.S.A.	122	223	71
Commercial	U.S.A.	122	223	97
Trogdon	U.S.A.	122	166	27
FC 32977	U.S.A.	122	223	127
Danish	U.S.A.	122	160	102
839	Spain	122	223	20
766	Spain	122	223	98
I.O.G.I.	U.S.A.	122	223	103
I.O.G.6.	U.S.A.	122	223	148
866	Spain	122	223	117
Von Komekes	Germany	122	223	81
Danish F.I.	Kenya	122	223	89
*Currie	Australia	125	160	59
*Neptune	Australia	125	160	55
*Barenza	Holland	125	160	8
*Svalofsfrode	Sweden	125	160	3
*Danish	Denmark	128	160	31
*Gullaker	Sweden	133	160	4
*Coxa	Sweden	133	160	3
Commercial	U.S.A.	133	166	57
Wis. 52	U.S.A.	133	166	36
	Late Types			
Hercules	U.S.A.	142	166	4
Syn. 6	U.S.A.	142	166	6
Avon	U.S.A.	142	166	27
M211142	U.S.A.	142	166	38
*C 23	N. Zealand	142	160	1
S 26	England	142	223	13
935	Spain	142	223	86
S 2	France	142	223	65
Akaroa	N. Zealand	142	223	2
*Grasslands	N. Zealand	149	160	2
Adefa 2	Denmark	154	166	2
*Svalofsbroge	Sweden	160	160	1
*S 26 F1	Kenya	160	160	1
Melle	Denmark	171	223	13
233	U.S.A.	180	166	0
S 37	England	194	223	14
S 143	England	194	223	2
Oron	U.S.A.	194	223	70
S 3	France	194	223	46
P 2453	U.S.A.	—	223	0
*Tardus 2	Sweden	—	160	0
*Tammisto 2	Sweden	—	160	0

*1957 sowings, the remainder being 1956 sowings.

Table II—Cocksfoot Ecotypes (F.A.O. Collection)

(*All* 1957 *sowings*)

Origin and Type	No. of Ecotypes	Days from sowing to flowering		No. of ecotypes within each pancile class		
				No. of panicles/yd.		
		Mean	Range	0–49	50–99	100<
Cyrenaica:						
Early	2	115	112–119	—	—	2
Late	0	—	—	—	—	—
Tripolitania:						
Early	3	117	112–119	—	—	3
Late	0	—	—	—	—	—
Greece:						
Early	8	119	112–125	2	6	—
Late	1	142	—	1	—	—
Iran:						
Early	10	119	112–133	8	2	—
Late	0	—	—	—	—	—
Morocco:						
Early	32	115	100–133	4	12	16
Late	1	142	—	1	—	—
Portugal:						
Early	16	124	119–133	1	3	8
Late	2	145	142–149	2	—	—
Algeria:						
Early	16	125	119–133	5	9	2
Late	2	135	133–142	2	—	—

in Table III. It will be seen that though there were approximately twice as many flowers at the second count in 1956 compared with the first, the timing of the counts did not materially change the ranking of the strains in relation to their flower production. The late flowerers produced but few flowers even at the second count. It will also be seen that a count of the same strains in 1957 produced very similar rankings to those found in 1956, the year of sowing. There is an indication that strain 233, alone, flowered better in the second year than in the first.

Table III—Cocksfoot Panicle Counts

Strain	First year Counts		Second year Counts on 9–9–57
	On 8–12–56* 166 days from sowing	On 30–1–57 219 days from sowing	
Commercial (U.S.A.) ..	56·7	127·0	63
M211142 (U.S.A.)	38·0	82·0	104
Wis. 52 (U.S.A.) ..	36·5	83·0	43
Trogdon (U.S.A.)	27·0	59·5	79
Avon (U.S.A.) ..	26·7	78·0	60
Syn. 6 (U.S.A.) ..	6·2	39·0	43
Hercules (U.S.A.)	3·7	13·0	28
Adefa 2 (U.S.A.)	1·7	22·0	38
233 (U.S.A.) ..	0	8·5	48
s.e.	8·5	19·0	31

*Mean of 4 replications, the other counts being the mean of two.

Perennial Ryegrasses

Data for these are shown in Tables IV and V. The 1956 sowings flowered but little, the interval from sowing to emergence being 151 days for the two earliest strains and ranging up to 222 days for those of the remainder which did actually flower. The panicle count showed, as might be expected, that the bred strains from Northern Europe were very shy to flower. The similarity of the first and second year counts indicate that there is no carry-over effect of temperature or photo-periodism from one season to another.

Table IV—Bred Perennial Ryegrass Strains

Strain	Origin	No. of days from sowing to flowering	No. panicles/yd.		
			First year Counts		Second year Counts 31–10–
			*8–12–56	†1–2–57	
Sel. A ..	Kenya	151	29	91	48
Melle (Hay)	Denmark	198	15	61	17
S.24 ..	England	222	1	2	3
S.23 ..	England	222	2	—	0
N. Zealand	N. Zealand	222	6	11	3
Odenwalders	Germany	222	1	2	9
Trianon ..	France	222	1	1	8
Von Komakes	Germany	222	3	10	3
Primavere	France	222	2	16	3
S.101 ..	England	222	0	1	0
Danish L/F	Denmark	222	0	6	3
Lembkes	Germany	222	0	11	15
Melle (Past)	Denmark	222	0	0	0

*222 days from sowing. †271 days from sowing.

Table V—Perennial Ryegrass Ecotypes and Bred Strains

Strain	Origin	No. of days from sowing to flowering	No. panicles/ yd. 8–10–57*
FAO 3062	Cyrenaica	98	93
FAO 3079	Cyrenaica	98	427
FAO 3235	Algeria	113	5
FAO 3244	Algeria	113	32
FAO 3275	Algeria	113	95
FAO 3212	Algeria	122	90
Sel. A. F2	Kenya	122	122
FAO 3179	Algeria	133	47
FAO 3223	Algeria	133	69
FAO 3266	Algeria	133	7
FAO 3316	Algeria	133	5
FAO 3661	Greece	133	14
FAO 3711	Iran	133	18
FAO 3209	Algeria	138	77
FAO 3257	Algeria	138	22
FAO 3291	Algeria	138	40
FAO 3651	Greece	138	1
Cluny	Australia	138	70
FAO 3151	Algeria	150	61
Colac	Australia	150	21
FAO 3111	Algeria	157	68
FAO 3140	Algeria	157	66
FAO 3314	Algeria	157	102
FAO 3193	Algeria	163	37
FAO 3652	Greece	163	19
FAO 3680	Greece	163	33
FAO 3650	Greece	171	1
Barenza (P)	Holland	—	0
Barenza (H)	Holland	—	0
FAO 3639	Greece	—	0
FAO 3659	Greece	—	0
FAO 3768	Iran	—	0

* 190 days from sowing.

The 1957 sowings (Table V) showed quite a different picture in that though the bred strains behaved as did those others from high latitudes which were sown in 1956, the ecotypes from the Mediterranean flowered quite early and reasonably well. The range in flowering time was from 98 days for the earliest ecotypes to 171 days for the latest. It is of interest that those which were the shyest to flower came from Greece.

Timothy

Observations during previous years have shown that the timothy strains from Northern Europe were shy to flower, and were poor yielders of herbage. They have, however, a possible use on vleis and so in 1956 ten North American strains were sown but no detailed record of emergence was kept. Counts of the number of panicles in a yard length of row were done in the second year (1957). The strains Drummond, Swallow, Itasca, Lorain, Milton, Climax, Hopkins, and a commercial lot, produced only single figure numbers of panicles. The Marietta strain, however produced 81 panicles.

Bromus inermis strains

This species behaves locally much like the timothy strains in relation to growth and flowering. The American strains Achenbach, Lancaster, Manchon and Lyon do not flower at all, while Fischer, Southland, Lincoln (5624), Lincoln, (6513), and a German strain produce but few flowers even in their second season.

DISCUSSION

The general effect of day-length and temperature on the induction of flowering of cocksfoot from the high latitudes is known for a few strains. Tincker (1925) suggested that it flowered best given long day-lengths. Gardner and Loomis (1953) found with three strains that induction occurred when short-day exposure preceded exposure to low temperatures and when short days and low temperatures were applied separately. They distinguish between a hormonal induction of flowering, an initiation of flowering when morphological changes become visible at the meristems, and the subsequent emergence and development of the inflorescence. Progressively higher temperatures and longer day-lengths are needed for each of these stages if seed production is to reach its maximum. Hanson and Sprague (1953) found, also, that low temperatures and short days (10 hours) followed by high temperatures and long days resulted in shortest heading time. Low temperature exposure gave the greatest number of heads.

The present work shows that there are large differences between the bred cocksfoot strains in relation to their flowering in short-day and comparatively high temperature conditions. The bred strains which flowered most locally, i.e. Danish, American commercial (FC 32977), and the American 1OG6, produced only from 102 to 148 panicles a yard. At the other end of the scale the worst flowerers were all strains such as the Aberystwyth "S" strains or similar types from North Europe or New Zealand. These produced often no flowers at all. An example from this group is S 37 cocksfoot which produced only 14 panicles a yard locally compared to the 120 to 225 fertile tillers a yard (depending on the nitrogen supply) reported by Evans (1953 and 1954) in England. It would seem therefore, that the grass breeders' success in breeding persistent and leafy cocksfoots has resulted in strains which, though seeding well in high latitudes, are more demanding in their low temperature and day-length requirements than are the commercial or early flowering strains.

Considering next the perennial ryegrasses, Cooper (1951 and 1952) has clearly shown that most plants are only able to flower after exposure to low temperatures. The results reported here show that the bred strains are more demanding in their temperature requirements than are many of the cocksfoots. Of the strains sown, all of which came from high latitudes, none showed any disposition to flower well locally with the exception of Cluny from Australia. A flowering strain could, however, be selected quite quickly as evidenced by the flowering of the local F_1 and F_2 selections from Irish ryegrass. The Mediterranean ecotypes with the exception of those from Greece, flowered reasonably and could well form the basis for local breeding work. Even so their panicle counts were comparatively small by temperate standards. Evans (1954) for example, showed that S 23 ryegrass produced from 561 to 784 fertile tillers in a yard drill, depending on the amount of nitrogen provided.

Turning to the timothies, Hanson and Sprague (*loc. cit.*) showed that it did not respond to different temperatures under 10-hour day-length conditions, but headed earliest when transferred to high temperatures and long days. Langer (1955) showed that S 48 timothy does not normally require low temperatures or short days for flower inductance. Keller and Patterson (1950) also found no real differences in heading so long as the day-length was over 10 hours. Day-length would thus seem to be the main factor which affects flowering in timothy, but the present results show that a steady 12-hour day is not enough to induce flowering in American timothy strains, with the exception of the Marietta strain which flowered moderately well in its second year.

The results as a whole, show that there is no lack of material for local selection and breeding, but whether (excluding problems of rust resistance and seed shattering both of which are important locally) such work should start from the locally flowering strains, which are often relatively stemmy or whether from the shy seeders which are more leafy, is a matter for debate. The lack of any carry-over effect of temperature and day-length from one season to another means that a single season's observations will serve as a basis for the rough ranking of strains and selections into those which are most suited for seed production locally and amongst which selection could profitably be done.

CLIMATE

The climatic factors of day-length, temperature, and rainfall, as recorded from a standard screen and equipment about 300 yards from the plots, are shown in Table VI. The small variation in day-length on the Equator when compared with that in temperate latitudes needs no emphasis. The small fluctuations in monthly mean temperatures are usual in equatorial climates. The minimum temperatures at ground level were not recorded, but previous observations have shown that in a natural grass sward they regularly drop to 33° or 35° F., hoar frosts occurring quite often in hollows and depressions. The accumulative temperatures (above 42° F.) during the year follow a regular pattern, varying from a maximum of just over 400 degrees a month in March, falling steadily to around 275 degrees in July, August and September, and then rising again.

TABLE VI—METEOROLOGICAL RECORDS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall (″)												
1956 ..	7·49	3·54	4·44	6·79	6·35	6·79	8·19	15·22	5·30	2·65	1·06	1·01
1957 ..	3·29	0·04	3·62	6·02	7·57	6·11	5·22	4·18	1·24	0·84	3·20	
Day length* (Hours/minutes)												
1957 0° ..	12·32	12·50	12·48	12·48	12·50	12·52	12·52	12·52	12·50	12·48	12·48	12·52
1957 50° N	8·32	10·29	12·06	14·06	16·00	17·28	17·44	16·30	14·32	12·42	10·54	9·40
Temperatures (°F)												
1956 max.	63·3	65·6	67·2	66·8	65·2	63·5	63·0	62·0	64·3	63·8	62·0	64·7
1956 min.	41·1	41·4	40·2	40·7	41·0	37·7	38·2	39·4	37·8	36·8	43·4	39·5
1956 mean	52·2	53·5	53·7	53·7	53·1	50·6	50·6	50·7	51·0	50·3	52·7	52·1
1957 max.	66·5	69·1	69·1	68·0	66·9	64·1	64·6	64·8	67·5	69·9	61·8	64·0
1957 min.	38·3	38·6	41·5	41·0	44·8	41·7	37·3	36·4	38·9	42·5	45·7	47·0
1957 mean	52·4	53·8	55·3	54·5	55·8	52·9	50·9	50·6	53·2	56·2	53·7	55·5

*As Civil Twilight hours, i.e. the interval between the sun being six below the horizon at dawn to the time it is six below the horizon at dusk. Data from the *Nautical Almanack*, 1956.

SUMMARY

Records of the dates of flower emergence, and of the numbers of panicles exserted in a yard length of row were kept for cocksfoot (*Dactylis glomerata L.*), perennial ryegrass (*Lolium perenne L.*) and timothy (*Phleum pratense L.*) strains. A great range in the times of flower emergence and panicle numbers was found between bred strains of the cocksfoots and to a lesser extent between bred strains of the ryegrasses and timothies. The interval from sowing to flower emergence ranged from 119 days to 194 days among the bred cocksfoots, and from 151 to 222 days among bred ryegrasses. Ecotypes of the cocksfoots from the Mediterranean region flowered between 119 to 149 days from sowing, while the range among the perennial ryegrass ecotypes was from 98 to 171 days from sowing. Bred, leafy strains of the cocksfoots from high latitudes produced very few panicles compared with the numbers produced by commercial strains or the ecotypes. With the exception of the Cluny strain from Australia, the bred perennial ryegrasses produced very few panicles, but many of the ecotypes flowered reasonably well under local conditions. Only one strain of timothy flowered well. Selection for leafiness in high latitudes has generally resulted in strains that are more demanding in their day-length and temperature requirements than commercial or naturally occurring ecotypes from the Mediterranean region.

ACKNOWLEDGMENTS

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VARIATION IN GESTATION PERIODS OF ZEBU CATTLE UNDER RANCH CONDITIONS

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(*Received for publication on 27th June, 1958*)

There have been several published observations of mean gestation periods for various Indian breeds of Zebu cattle, but there is little information available about the gestation periods of the East African Zebu, and advantage was therefore taken of facilities afforded by an experiment in reproductive physiology to study the gestation periods of 182 East African Zebu cows in Tanganyika for which unusually accurate data were available.

MATERIAL

From November, 1956, to December, 1957, a herd of nearly 250 empty, mature East African Zebu cows, comprising some Boran, some miscellaneous indigenous Tanganyika shorthorned Zebus, and a few crossbreds between these two types, was under close observation for reproductive behaviour at Mkata Ranch, situated at an altitude of about 1,200 ft. in the Eastern Province of Tanganyika.

All service bulls were Borans. They were raddled with coloured pigments mixed in hot tallow and painted on to the brisket, dewlap, and inside of the forelegs, every morning and evening; and a team of observers was on duty throughout the day and night to record the times of every service. During the night the cattle were confined in thorn-hedge enclosures which were illuminated by floodlights from an elevated observation post in which observers were constantly on duty.

After a recorded service, cows were examined by rectal palpation every six hours to check ovulation. Seven to ten days later they were again examined to check the development of corpora lutea, and at least twice subsequently, approximately six weeks and three months later, to check pregnancy. In any cases of doubtful pregnancy at six weeks, a further prenancy examination was made at seven weeks.

The bulls were serving from the middle of November until early March, but, owing to experimental treatments, all the cows were not receptive to the bulls regularly during this period. When the bulls were removed, the herd was left in charge of two African herdboys, but every animal was checked every night and morning by a Veterinary Assistant to record times of calving or abortion to the nearest 12 hours.

From these observations 182 gestations, which resulted in the birth of living calves, were recorded, concerning which there was absolute certainty of date of conception and date of calving, excluding all other gestations involving any element of doubt, such as that arising from split-oestrus involving services on two days at one or two days interval, and cases of double services within one or two weeks when there was any doubt at pregnancy diagnosis about the service responsible for conception. No gestation was excluded because of its apparently abnormal length. Gestation periods were recorded, for the purposes of computation, as intervals between the date of conception and date of calving, measured in days and ignoring the time of day.

RESULTS

The mean gestation period for the whole group was 282.7 days. The longest gestation period recorded was 296 days for a male Boran calf born in October, and the shortest period was 270 days for a female calf of a Tanganyika Zebu cow which calved in September. The standard deviation for the undifferentiated whole group was 4.7 days.

The data were grouped according to estimated breed-type of cow (based on appearance and knowledge of general mating programme of the ranch), sex of calf, and month of calving. For the purpose of the latter classification, August and September were treated as one month, as very few cows calved in August and none before the 26th, and November and December were also counted as one month because very few cows calved in December. There were no multiple births. Approximately equal numbers of cows calved during the day-time (49 per cent) and during the night-time (51 per cent).

The numbers of animals in each sub-group, and the mean gestation periods of each sub-group, are shown in Table I.

TABLE I—MEAN GESTATION PERIODS OF EAST AFRICAN SHORTHORNED ZEBU COWS CLASSIFIED BY BREED-TYPE OF COW, SEX AND CALF, AND MONTH OF CALVING

Sex of Calf	Breed-type of Cow	Month of Calving						Main Groups	
		Aug.–Sept.		October		Nov.–Dec.			
		No.	Mean	No.	Mean	No.	Mean	No.	Mean
Male	Tanganyika ..	17	283·8	17	282·8	11	286·1	45	284·0
	B. x T. ..	5	278·8	7	283·1	2	287·0	14	282·1
	Boran	7	281·9	13	284·8	7	286·3	27	284·4
	All breeds ..	29	282·5	37	283·5	20	286·3	86	283·8
Female	Tanganyika ..	14	279·9	28	280·2	13	284·1	55	281·0
	B. x T. ..	5	280·2	8	281·4	—	—	13	280·9
	Boran	6	281·2	14	283·2	8	284·5	28	283·1
	All breeds ..	25	280·2	50	281·2	21	284·2	96	281·6
Both sexes	Tanganyika ..	31	282·0	45	281·2	24	285·0	100	282·4
	B. x T. ..	10	279·5	15	282·2	2	287·0	27	281·6
	Boran	13	281·5	27	284·0	15	285·3	55	283·8
	All breeds ..	54	281·4	87	282·2	41	285·2	182	282·7

The mean gestation period for these East African Zebus was slightly shorter than those of the Indian Zebu breeds, Sahiwal (283.4), Red Sindhi (283.2), and Tharparkar (284.7) reported by Anantakrishnan *et al.* (1952) from Indian data, and is considerably shorter than those reported by Villares and De Abreu (1949) for Ongole (291.5), Kankrej (291.9) and Gir (285.1) Indian Zebus from South American data. Reports of shorter gestation periods of Zebu cattle are given by Rigor (1949), who found gestations varying from 252 to 299 days, with a mean of 280 days, for Red Sindhi cattle in the Phillipines, and by Manucarov (1951), who also records an average gestation of 280 days for Zebu cattle when carrying Zebu calves derived from a foundation herd used for cross-breeding purposes at Azerbaijan. Manucarov's data are unusual in that the cross-bred cows were derived from Brown Swiss (which normally have a characteristically long gestation of about 290 days) and the Zebu had even shorter gestations of only 268.3 days.

An analysis of variance on the present data was carried out, and results are summarized in Table II.

DISCUSSION

That there should be a highly significant difference in gestation period attributable to the sex of the calf is expected, and conforms to the general pattern of variation in gestation periods of *Bos taurus* breeds, although the difference of 2.2 days longer for male calves in this sample is rather greater than most reported differences, but is in agreement with that reported by Jafar *et al.* (1950) in respect of a herd of Friesian cattle in the United States. The highly significant effect of season of calving within such a short period of time is of interest in the present data.

TABLE II—ANALYSIS OF VARIANCE OF DATA PRESENTED IN TABLE NO. 1

Source of variance	d.f.	m.s.	F.
Sexes (S)	1	218·0	11·66***
Breed-types (B) ..	2	54·5	2·91 NS
Months (M) ..	2	183·5	9·81***
Interactions:			
S. x B.	2	15·5	0·83 NS
S. x M.	4	20·3	1·09 NS
B. x M.	2	2·0	0·11 NS
Within Identical sub-classes	168	18·7	

Standard deviation within sub-classes, 4·3 days.

*** indicates statistical significance at $P<0·001$.
NS indicates not significant.

Reports from the United States by Brakel *et al.* (1952) and by Erb (1955) are in agreement that *Bos taurus* gestations terminated during the spring tend to be about two days longer than those terminated in the autumn, but the trend in the present data is considerably steeper.

Gestations terminated in October were only 0.8 days longer than those terminated one month earlier, in September, but they were 3.0 days shorter than those terminated only a month later, in November.

The most likely explanation appears to lie in the progressively rapid deterioration in the nutritive value of the available grazing which occurs in Tanganyika towards the end of the prolonged "dry season". At Mkata the last rain of the "rainy season" fell in early June (0.17 in.) and thereafter there was no rain until late November (0.25 in.). During this period the combined effects of atmospheric temperatures of 70-80° F., desiccating winds, and a progressive shortage of grazing, which was accentuated this year by grass fires in the reserve "dry-season" grazing areas, would combine to reduce the plane of nutrition of the cows during the final stages of pregnancy when the demands of the developing calf are most rapidly increasing.

The same explanation could apply to the American observations in that the spring-calving cows would probably tend to be on a lower average plane of nutrition during late pregnancy than the autumn-calvers.

There was no significant difference between the mean gestation periods of the three breed-types, although the mean gestation period of the Boran-type was 1.4 days longer than that of the smaller Tanganyika Zebu type.

Jafar *et al.* (1950) reported a very significant positive correlation between size of cow and length of time the cow carried her calves in Friesian cattle.

To ascertain whether the size of the cow was affecting the gestation period in these data, height and girth measurements of all cows taken at the beginning of pregnancy were used to compute estimated liveweights (from a previously computed nomogram) and the covariances between gestation period and estimated liveweight, and between gestation period and height were calculated in the group as a whole and within breed-types.

There was a highly significant ($P < 0.01$) regression of gestation period on estimated liveweight within the whole group, and a less significant ($P < 0.05$) regression, of similar order within breed-type groups:—

$b = + 1.04 \pm 0.75$ days per 100 lb. estimated liveweight in the whole group.

$b = + 1.06 \pm 1.03$ days per 100 lb. estimated liveweight within breed-type sub-groups.

The means and standard deviations of estimated liveweights and heights for each breed-type group are given in Table III.

TABLE III

	Estimated liveweights	Height over "hooks"
Tanganyika Zebu	464·9 ± 59·1 lb.	44·14 ± 1·55 in.
Boran x Tanganyika Zebu ..	513·1 ± 49·1 lb.	45·64 ± 1·00 in.
Boran	605·8 ± 82·7 lb.	48·11 ± 1·75 in.

Thus on the basis of the regression of gestation period on estimated liveweight the Boran group would be expected to have a mean gestation period of $\frac{140.9 \times 1.06}{100} = 1.49$ days longer than the Tanganyika Zebu group if they had all been of the same breed. As this figure compares very closely with the actual difference of 1.4 days, the difference in size would be an adequate explanation of the trend towards longer gestations in the Boran group.

The mean gestation of the cross-bred group does not appear to follow this regression, but this is largely attributable to the chance distribution of gestations of cross-bred cows falling disproportionately into the early-calving groups. If the mean gestation of the cross-bred groups is corrected to the same proportional distribution over the season as the mean distribution of the other two breed types it becomes 282.6 days, which conforms with the expectation of 282.9 days based on the mean size of this group relative to that of the Tanganyika Zebu group.

The Occurrence of Oestrus During Pregnancy

A total of 15 cows out of 209 which calved during the experiment (7.2 per cent) manifested signs of oestrus adequate to cause a bull to mount when the cows were already pregnant.

None of their gestations have contributed to the statistics presented in the first part of this paper on the grounds of the irregularity of behaviour of the cows, but it is relevant to consider the actual gestation periods, as determined by detailed knowledge of ovarian function and early pregnancy diagnoses, and the "apparent gestation" periods which would be recorded if gestation was assumed to be the number of days between the date of last recorded service and calving. This comparison is presented in Table IV.

Table IV—Comparison of Actual and "Apparent" Gestation Periods of 15 Cows which were Served During Pregnancy

Cow	Gestation Period.		Cow	Gestation Period	
	Actual	Apparent		Actual	Apparent
32	279	260	156	275	242
37	276	246	158	290	270
47	287	275	179	278	217
60	283	270	191	274	211
89	280	244	197	287	237
102	288	276	263	293	272
120	282	222	288	285	249
127	285	261			
			Mean	282·8	250·1

The fact that cows do sometimes exhibit signs of oestrus when pregnant has been recognized for a considerable time. Henderson (1938), reporting a study of reproductive histories of a large dairy herd of mixed breeds in New York State, stated "many cows, of course, showed estrum while safely pregnant". Knapp *et al.* (1940) quoted six cases out of 133 calving cows (4.5 per cent) in the Beltsville herds, in Maryland, which accepted service when pregnant, and Donald (1943), and Branton (1949), have both estimated the expectancy of this occurrence in about 3.5 per cent of pregnancies in populations of *Bos taurus* dairy cattle.

The higher incidence in the present data may have resulted from the greater detail available which has enabled identification of cases which might otherwise have been overlooked. Thus a preliminary examination of the present records would reveal eight cows which were heavily pregnant when served (3.8 per cent), whereas the remaining seven cows were served when in early pregnancy, and only the combination of detailed ovary-histories and early pregnancy diagnoses enabled positive identification.

The effect of including "apparent" gestation periods in less critical studies of variation in gestation periods of various cattle populations would be to reduce the estimated mean below the true mean, and to overestimate the variance.

The consideration of greater practical significance is the element of error which such occurrences will tend to introduce into pedigree records. The seven "apparent" gestations of over 259 days might reasonably have been accepted by stud breeders as "normal", or only slightly premature, and each could have resulted in an incorrect paternity record entered in good faith by the breeder. Such errors constitute a hazard to accurate pedigree breeding, and it is suggested that stud book societies, and others concerned with such records, might usefully adopt the rule that all "repeat" services or inseminations of a cow, whose progeny is to be registered, shall be carried out with the semen of the same bull as that which was used for her previous mating or insemination if the "repeat" occurs within 40 days. Such a safeguard combined with a record of the service or insemination, from which to compute a gestation period for consideration, should remove doubt from all but a very small proportion of paternity disputes.

SUMMARY

Records of 182 gestations which terminated in live births of East African Zebu cows, comprising 100 Tanganyika shorthorned Zebus, 55 Borans, and 27 cross-breds between these two types, held under ranch conditions in Tanganyika, were statistically examined. The mean gestation period was 282.7 days, with a standard deviation of 4.7 days in the undifferentiated data.

There was no significant difference between breed type, but there was a highly significant regression of +1.04 days ±0.75 days per 100 lb. liveweight which accounted for the recorded difference between mean gestation periods of each breed type.

There was a highly significant effect of sex of calf—males being in utero 2.2 days longer than females—and a highly significant effect of month of calving attributed to the rapid deterioration in plane of nutrition under ranch conditions towards the end of the dry season—November calvings followed gestations which were 3.0 days longer than those terminated in October, which were 0.8 days longer than those terminated in September.

During 7.2 per cent of 209 gestations cows were served whilst definitely pregnant.

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REVIEWS

NATURE STUDY FOR SCHOOLS—INSECTS, by G. F. Thistleton, published by Evans Brothers Ltd., London, 1958, 152 pp., price 10*s.* 6*d.*

This elementary entomological textbook is written with the emphasis on practical instruction in schools and on providing basic information for farmers on insects in general.

A simple, but adequate account of the diagnostic characteristics of insects, reasons for studying them, methods of collection and storage and their processes of development, is followed by a description of the most important orders. The distinguishing features, life cycles, habits and habitats of the main groups within each order are described with the minimum of scientific terminology and clear illustrations of representative types are included. The book ends with useful chapters on breeding and caging, nomenclature, points of general interest, and a glossary of common and scientific names of some of the more familiar insects. As an introduction to the subject and a stimulant to the interest of students and farmers in the practical aspects of entomology, this clearly written book is eminently suitable.

S.J.C.

DAIRY CATTLE BREEDING IN THE TROPICS, by P. Mahadevan. Technical Communication No. 11 of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh. Published by the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1958, 88 pp., price 15*s.*

A very useful book, short and to the point. It is especially recommended for East Africa and, indeed, for any tropical area. The author has assembled much of the knowledge available on tropical cattle generally, and has presented it in a way which will be of use to the research worker, the agricultural adviser and the thinking farmer alike. Among the subjects discussed are body weight, milk yield and composition, age at first calving, the calving interval, length of lactation, mortality, inheritance of economic characters, selection and breeding. In the present non-specialized cattle populations, many of these findings apply also to the breeding of beef-type cattle. For those who wish to study any particular aspect further, a list of references is available at the end of each chapter. The book forms a definite contribution towards placing the breeding and the management of tropical cattle in their proper perspective.

K.L.

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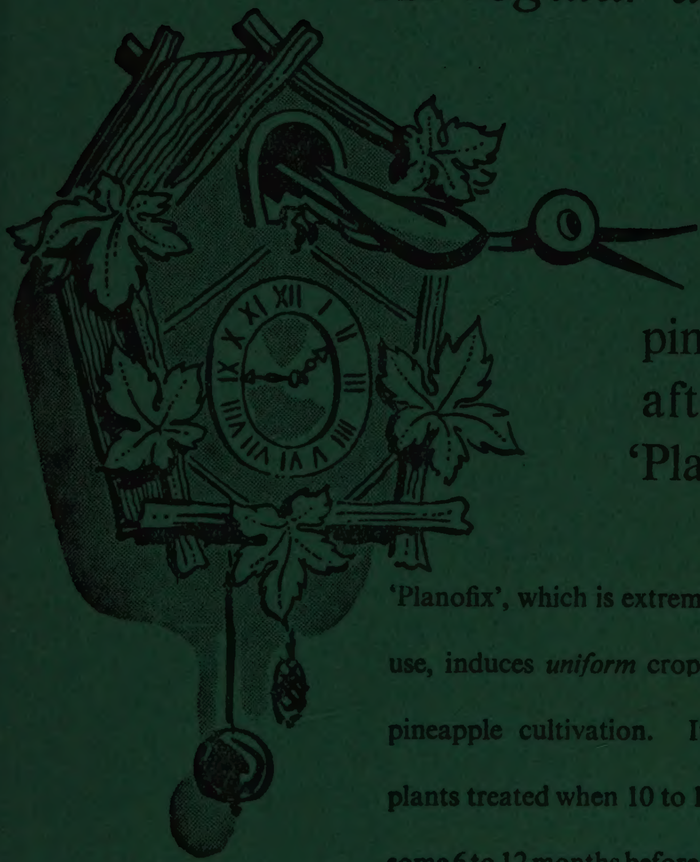

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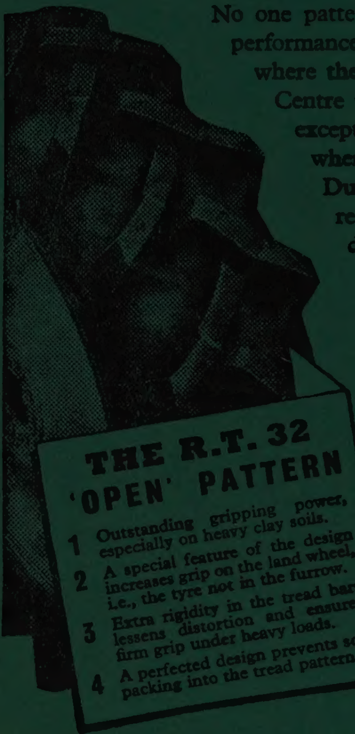

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